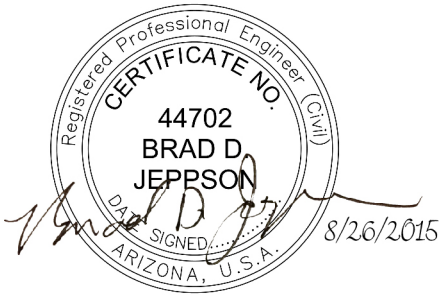
CITY OF SEDONA

SEDONA, ARIZONA

INJECTION WELLS NO. 1 AND NO. 2 EQUIPPING DESIGN

TECHNICAL SPECIFICATIONS
DIVISIONS 02 - 17

BID SET
August 2015



EXPIRES 06-30-2018

City of Sedona

INJECTION WELLS NO. 1 AND NO. 2 EQUIPPING DESIGN

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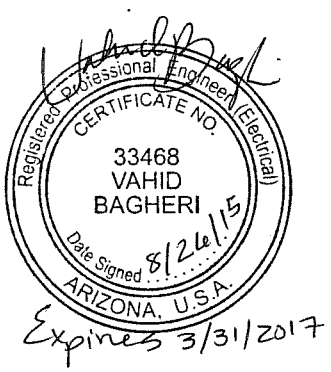

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SECTION 02050

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Gravel.
   2. Imported Fill.
   3. Native Material.
   4. Sand.
   5. Select Material.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C 131 - Standard Test Method for Resistance to Degradation of Small-Size Course Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. C 535 - Standard Test Method for Resistance to Degradation of Larger-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   5. D 422 - Standard Test Method for Particle-Size Analysis of Soils.
   6. D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   7. D 2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
   8. D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   9. D 4829 - Standard Test Method for Expansion Index for Soils.
   10. D 5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.

B. Sponsored and Distributed by the Maricopa Association of Governments (MAG) - Arizona, 1998 Edition, with updates:
   1. Uniform Standard Specifications for Public Works Construction.

1.03 SUBMITTALS

A. Product data:
   1. Material source.
   2. Gradation.
   3. Testing data.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.
   2. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

B. Gravel:
   1. Consist of hard, durable particles or fragments of stone or gravel, screened or crushed to specified sizes and gradations.
   2. Free from organic matter, lumps or balls of clay, alkali, adobe, or other deleterious matter.
   3. When sampled and tested in accordance with specified test methods, material shall comply with following requirements:
      a. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C 131.
      b. Plasticity index: Not greater than 5 when tested in accordance with ASTM D 4318.
      c. Liquid limit: Not greater than 25 percent when tested in accordance with ASTM D 4318.
   4. Conform to sizes and grade within the limits as follows when tested in accordance with ASTM C 117 and C 136:

Sieve Size (Square Openings)	**Percent By Weight Passing Sieve**	
	Type A	**Type B**
3 inch	100	--
1-1/2 inch	--	100
Number 4	30 - 75	30 - 70
Number 8	20 - 60	20 - 60
Number 30	10 - 40	10 - 40
Number 200	0 - 12	0 - 12

C. Imported material:
   1. Native soils with a soil classification ‘SM’ and “SC’ with the gradation presented below are suitable for use in engineered pad fill and tank wall backfill, provided they can be properly compacted and screened of any oversize material greater than 3 inches.

Specification	Common	Engineered Fill Below Foundations[1]
Passing 3"/75 mm	100%	100%
Passing #200/0.075 mm	≤60%	15-45%
Liquid Limit	<40%	<35%
Plasticity Index	<18%	<15%
Swell [2]	<1.5	<1.5

Notes:

(1) Cinder based products may be used below foundations provided they meet the required specifications.

(2) Swell potential when compacted to 95 percent of maximum dry density (ASTM D-698) at a moisture content of 2 percent below optimum, confined under a 100 psf surcharge, and inundated.

D. Native material:
   1. Sound, earthen material passing 3-inch sieve.
   2. Percent of material by weight passing Number 200 sieve shall not exceed 30 when tested in accordance with ASTM D 422.
   3. Expansion index less than 35 when tested in accordance with ASTM D 4829.

E. Sand:
   1. Clean, coarse, natural sand.
   2. Nonplastic when tested in accordance with ASTM D 4318.
   3. One hundred percent shall pass a 1/2-inch screen.
   4. No more than 20 percent shall pass a Number 200 sieve.

F. Select native material:
   1. Sound earthen material for which sum of plasticity index when tested in accordance with ASTM D 4318 and the percent of material by weight passing Number 200 sieve shall not exceed 23 when tested in accordance with ASTM D 422.
   2. Organic content shall not be greater than 3 percent by volume.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 02084

PRECAST DRAINAGE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Onsite utility structures:
   1. Precast concrete manholes.
   2. Precast drainage inlets.
   3. Standpipes for irrigation or drainage pipes.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02318 - Trenching.
      b. Section 03300 - Cast-in-Place Concrete.
      c. Section 05500 - Metal Fabrications.
      d. Section 07900 - Joint Sealants.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
   2. C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
   3. C 857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   4. C 858 - Standard Specification for Underground Precast Concrete Utility Structures.

1.03 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Manholes and appurtenances: Manholes and appurtenances shall be watertight and free from infiltration or exfiltration.

1.04 SUBMITTALS

A. Shop drawings: Submit shop drawings for precast utility structures.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Precast concrete manholes:
   1. Construct precast concrete manholes in accordance with design, size, shape, form, details, and at locations indicated on the Drawings and specified.
   2. Construct manholes of precast eccentric or concentric manhole units in accordance with the requirements indicated on the Drawings and specified.
   3. Provide precast, cylinder units, taper sections, and eccentric flat top sections meeting strength requirements in accordance with ASTM C 478.
   4. Base design and manufacture to A-16 (HS 20-44) loading in accordance with ASTM C 857.
   5. Construct precast manhole sections of Class D concrete as specified in Section 03300 to form and dimensions indicated on the Drawings.

B. Precast drainage inlets:
   1. Construct precast concrete drainage inlets in accordance with the size, shape, form, details, and at locations indicated on the Drawings and specified.
   2. Base design and manufacture to A-16 (HS 20-44) loading in accordance with ASTM C 857.
   3. In accordance with ASTM C 858.
   4. Construct precast drainage inlets of Class D concrete as specified in Section 03300 to form and dimensions indicated on the Drawings.

C. Standpipes for irrigation or drainage pipes:
   1. Pipe may be used in lieu of cast-in-place structures, as indicated on the Drawings.
   2. Use concrete pipe in accordance with ASTM C 361.
   3. Construct precast pipe of Class D concrete as specified in Section 03300 to form and dimensions indicated on the Drawings.

2.02 ACCESSORIES

A. Standpipes for irrigation or drainage pipes:
   1. Covers: As indicated on the Drawings.

B. Precast concrete manholes:
   1. Joint sealant: Use precast concrete joint sealant as specified in Section 07900.
   2. Manhole frames and cover sets: Type, size, and quality as specified in Section 05500 or as indicated on the Drawings.
   3. Drop manhole fittings:
      a. Drop tee and other fittings: Vitrified clay pipe or as otherwise specified or indicated on the Drawings.
   4. Piping penetrations through cylinder units:
      a. Install Kor-N-Seal, or equivalent, rubber gasket boots with steel clamps.
      b. Piping connections to the manhole bases shall be as indicated on the Drawings.

C. Precast drainage inlets:
   1. Covers: As indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Standpipes for irrigation or drainage pipes:
   1. Excavation and backfill: As specified in Section 02318.

B. Concrete manholes:
   1. Excavation and backfill: As specified in Section 02318.
   2. Precast concrete manholes:
      a. Manhole bases:
         1) Form and place concrete on undisturbed soil and/or on aggregate base course compacted to 95 percent of maximum density.
         2) Form that portion of base above invert elevation of sewer pipe to provide smooth channel section as indicated on the Drawings.
         3) Check forms for accuracy of dimensions and relative smoothness prior to placing concrete for base. Channels shall vary uniformly in size and shape from inlet to outlet if required.
         4) Construct of Class A concrete as specified in Section 03300 to form and dimensions indicated on the Drawings.
         5) Place base concrete as monolith.
      b. Manhole sections:
         1) Set each manhole section plumb.
         2) Use sections of various heights and adjustment rings to bring top of manhole ring and cover to required elevation.
      c. Joints:
         1) Seal joints with precast concrete joint sealant as specified in Section 07900 unless otherwise indicated on the Drawings.
         2) Clean joints with brush and prime.
         3) Apply precast concrete joint sealant as follows, except where instructions differ from manufacturer's printed instructions. Where these instructions differ from manufacturer's instructions, install precast concrete joint sealant in accordance with manufacturer's written instructions:
            a) Remove silicon treated protective paper from one side of preformed rope and lay preformed rope, paper side up, on cleaned joint surface. Press surface firmly end-to-end around entire joint, making minimum 1-inch laps where necessary.
            b) Remove protective paper from preformed rope and lower next section into place.
         4) Seal joints watertight.
      d. Manhole frame and cover sets:
         1) Install manhole frames and cover sets at locations indicated on the Drawings.
         2) Setting:
            a) Set manhole frames and covers at elevations and requirements indicated on the Drawings.
               (1) Set manhole covers flush with paving.
               (2) Where no paving exists, set manhole cover 6 inches above surrounding grade.

b) Where structure is outside limits of traveled shoulder but not in roadside ditch, place structure 1/10 foot or more above existing ground surface.
c) Where cover is in existing pavement or in traveled way of existing road shoulder, place cover flush with existing surface.
d) Where manhole cover falls in existing roadside ditch or right of way, place manhole cover approximately 1-1/2 feet above existing ground surface.
e) Set manhole frames at required grade and securely attach to top of precast manhole shaft unit or on adjustment rings, using cement mortar.
f) Setting covers:
(1) After frames are securely set in place in accordance with requirements specified, install covers and perform necessary cleaning and scraping of foreign materials from frames and covers as required to accomplish and to assure proper fit.
(2) Any frame and cover which creates noise when passed over by traffic shall be replaced.

3. Drop manholes:
a. Construct drop manholes at locations and in accordance with details indicated on the Drawings.
b. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
c. Furnish and set fittings as indicated on the Drawings.
4. Pipe stubs:
a. Provide pipe stubs at manhole locations and in conformance with details indicated on the Drawings and as specified.
b. Plugging stubs:
1) Plug stubs with vitrified clay stopper or brick plug as indicated on the Drawings.
2) Unless otherwise indicated on the Drawings, comply with following:
a) Stubs up to and including 21 inches: Vitrified clay stoppers.
b) Stubs greater than 21 inches: Brick plugs.

C. Precast drainage inlets:
1. Excavation and backfill: As specified in Section 02318.

3.02 FIELD QUALITY CONTROL

A. Tests:
1. Sanitary sewer manholes: Vacuum test all sanitary sewer manholes. Use following vacuum test procedures and requirements:
a. After completion of the manhole barrels but prior to backfilling and grade ring installation, seal all openings in the manhole with plugs and a rubber ring "donut" type plug inserted inside the opening of the cone.
b. Attach a small vacuum pump to a hose connected to the plug and apply 4 pounds per square inch of vacuum.
1) Allow vacuum to stabilize at 3.5 pounds per square inch for 1 minute, then begin the test.

2) The manhole must maintain vacuum such that no greater than 0.5 pounds per square inch of vacuum is lost during the specified test period.

c. The specified test period is as follows:

Manhole Depth (Feet)	Minimum Test Period (Minutes)
0-5	4.5
5-10	5.5
10-15	6.0
Greater than 15	6.5

d. Patch as required and retest manholes that fail the test.

e. Provide a vacuum regulator on the vacuum pump such that no greater than 4 pounds per square inch can be applied to the manhole during the test.

f. Repair all manholes that do not meet the leakage test, or are unsatisfactory from visual inspection.
   1) Retest after repair is completed.

END OF SECTION

SECTION 02200

SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Clearing, grubbing, and stripping project site.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01354 - Hazardous Material Procedures.
      b. Section 02050 - Soils and Aggregates for Earthwork.

1.02 REFERENCES

A. United States Code of Federal Regulations (CFR):
   1. 40 - Protection of Environment.
      a. 503 - Standards for the Use or Disposal of Sewage Sludge.

1.03 DEFINITIONS

A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.

B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.

C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the Engineer.

D. Sludge:
   1. Sludge contains both inert and organic material and is classified as a "Class B" product in accordance with 40 CFR 503.
   2. Dispose of sludge on a permitted land application site or in a permitted landfill.

1.04 QUALITY ASSURANCE

A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

1.05 PROJECT CONDITIONS

A. Environmental requirements:
   1. For suspected hazardous materials found: As specified in Section 01354.

1.06 SEQUENCING AND SCHEDULING

A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine site and verify existing conditions for beginning work.

3.02 PREPARATION

A. Protect existing improvements from damage by site preparation work.

3.03 INSTALLATION

A. Clearing:
   1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
   2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
   3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.

B. Grubbing:
   1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
   2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

Height of Embankment over Stump	**Depth of Clearing and Grubbing**
0 feet to 2 feet	Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.
2 feet to 3 feet	Grub stumps 1 foot and over in diameter to 18 inches below original grade. Cut others flush with ground.
Over 3 feet	Leave no stumps higher than stump top diameter, and in no case more than 18 inches.

   3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.

C. Stripping:
   1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
   2. Deposit stripped material in accordance with following requirements:
      a. At locations acceptable to Engineer.
      b. Use accepted material in top 6 inches of areas to be used for future planting.
   3. Replace topsoil where indicated on the Drawings.

END OF SECTION

SECTION 02238

ROCK REMOVAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Removal of rock during excavation and trenching by mechanical methods. Blasting shall not be allowed.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02300 - Earthwork.
      b. Section 02318 - Trenching.
      c. Section 03300 - Cast-in-Place Concrete.

1.02 REFERENCES

A. Associated General Contractors (AGS):
   1. Manual of Accident Prevention for Construction.

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Submit rock removal procedures including:
   1. Rock removal method, including equipment to be used.
   2. Method of screening or grading the rock for reuse as backfill.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify site conditions and note irregularities affecting work. Beginning work as specified in Section means acceptance of existing condition.

B. Determine best method of rock removal.

3.02 ROCK REMOVAL BY MECHANICAL METHOD

A. Excavate for and remove rock by mechanical methods.

B. Cut away rock at excavation bottom to form level bearing.

C. Remove shaled layers to provide sound and unshattered base for foundations.

D. In utility trenches, excavate to 6 inches below invert elevation of pipe and 24 inches wider than pipe diameter. At dedicated easements or rights of way, excavate 18 inches wider than pipe diameter.

E. Remove excavated material unsuitable for fill or backfill from site.

F. Correct unauthorized rock removal in accordance with backfilling and compaction requirements as specified in Section 02300, Section 02318, and as otherwise required.

3.03 FIELD QUALITY CONTROL

A. Visual inspection of bearing surfaces and cavities formed by removed rock.

3.04 ADJUSTING

A. Correct unauthorized rock removal or overbreak in accordance with backfilling and compaction requirements as specified in Section 02300.

END OF SECTION

SECTION 02260

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for designing, furnishing and installing, maintaining, and removing excavation support and protection.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.

1.02 REFERENCES

A. American Institute of Steel Construction, Inc. (AISC):
   1. Steel Construction Manual.

B. American Society of Civil Engineers (ASCE):
   1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

C. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
   1. Design Manual 7.2 - Foundations and Earth Structures.
   2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.

D. United States Steel Corporation (USS):
   1. Steel Sheet Piling Design Manual.

1.03 DEFINITIONS

A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.

B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.

1.04 SYSTEM DESCRIPTION

A. Where General Engineering Design Practice is specified, provide drawings and signed calculations and have design performed by civil or structural engineer registered in State where the Project is located:
   1. Provide design calculations that clearly disclose assumptions made, criteria followed, and stress values used for the materials being used.
   2. Furnish references acceptable to Engineer substantiating appropriateness of design assumptions, criteria, and stress values.

B. Design requirements:
   1. General:
      a. Design means for safe and stable excavations in accordance with general engineering design practice.
      b. Design steel members in accordance with the building code as specified in Section 01410 and the AISC Manual of Steel Design.
      c. Design shoring involving materials other than steel in accordance with building code as specified in Section 01410.
      d. Perform design in accordance with soil characteristics and design recommendations contained in a written geotechnical report issued and signed by a geotechnical engineer hired by the Contractor. Geotechnical engineer shall be registered in the state where the Project is located:
         1) Make copy of geotechnical report available at project site for Engineer's review.
         2) Retain and pay for geotechnical engineer's services.
         3) Obtain report based on soil samples, field and laboratory tests, and borings performed for the geotechnical report for the design of stability of excavations by the geotechnical engineer hired by Contractor.
      e. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in the AISC Steel Construction Manual and the building code as specified in Section 01410, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
      f. Minimum safety factor used for design shall not be less than 1.5.
      g. The calculated minimum depth of penetration of shoring below the bottom of the excavation shall be increased not less than 30 percent if the full value of passive pressure is used in the design.
      h. The maximum height of cantilever shoring above the bottom of excavation shall not exceed 15 feet.
         1) Use braced shoring when the height of shoring above the bottom of excavation exceeds 15 feet.
      i. The location of the point of fixity for shoring shall not be less than half the calculated minimum embedment depth below the bottom of the excavation.
      j. Generally acceptable references for the design of shoring and excavations are as follows:
         1) Caltrans California Trenching and Shoring Manual.
         2) NAVFAC Design Manual 7.2.
         3) NAVFAC Design Manual 7.3.
         4) USS Steel Sheet Piling Design Manual.
         5) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

k. The maximum total deflection at any point on the shoring shall not be more than 1/2 inch.
l. Shoring design and installation shall be performed by one of the following design firms, or approved equal. Include cost for this shoring design in bid:
    1) Ames Construction Co.
m. Shoring geotechnical report shall be performed by one of the following geotechnical firms. Include cost for the shoring geotechnical report in the bid:
    1) Speedie Associates, Flagstaff, Arizona.

2. Soldier piles and lagging:
    a. Provide lagging over the full face of the excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
    b. Provide full face lagging all around penetrations through the lagging.
    c. If the soldier piles are installed in predrilled holes, the predrilled holes shall be filled with control density backfill after the soldiers piles are installed.
    d. The effective width of driven soldier piles for passive soil resistance shall not exceed 2 times the width of the pile.
        1) The effective width of concrete encased soldier piles for passive soil resistance shall not exceed 2 times the width of the concrete encasement.
    e. Fill voids behind lagging with gravel or other material acceptable to the Engineer.
    f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles.
        1) Wales shall be back-to-back double channels or other members acceptable to the Engineer.
        2) Eccentrically loaded with section soldier piles or wales are not acceptable.
    g. Design soldier piles for downward loads including vertical loads from tie back anchors.
3. Soil anchors, rock anchors, and deadmen anchors:
    a. Design tie back anchors for a safety factor of not less than 2 times the calculated load from the shoring.
    b. Proof load all production anchors to not less than 125 percent of the calculated load from the shoring.
        1) Lock off anchors at the calculated anchor load.
    c. The length of soil anchors used to calculate resistance to load from the shoring shall not include any length within the potential active pressure soil failure zone behind the face of shoring.
    d. Design tie rods for anchors for 130 percent of the calculated load from the shoring.
    e. Design tie rods for anchors for 150 percent of the calculated load from the shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.

C. Performance requirements:
1. General:
    a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement

or movement of soils, alterations in ground water level caused by such excavations, and related operations.

b. Specified provisions:
    1) Complement, but do not substitute or diminish, obligations of Contractor for the furnishing of a safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of the Work, structures, and other improvements.
    2) Represent minimum requirement for:
        a) Number and types of means needed to maintain soil stability.
        b) Strength of such required means.
        c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.

2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain the stability of soils and rock.
3. Provide support for trench excavations for protection of workers from hazard of caving ground.
4. Provide shoring:
    a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
        1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
        2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
    b. For trenches 5 feet and deeper.
    c. For trenches less than 5 feet in depth, when there is a potential for cave-in.
    d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design and procedures for construction and maintenance to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
    a. Using stiff support systems.
    b. Following appropriate construction sequence.
    c. Preventing soil loss through or under support system:
        1) Provide support system that is tight enough to prevent loss of soil and extend deep enough to prevent heave or flow of soils from supported soil mass into the excavation.
    d. Providing surface runoff routing and discharge away from excavations.
    e. Where dewatering is necessary, recharge groundwater as necessary to prevent settlement in area surrounding excavation.
    f. Where sheet piling is used, use interlocking type sheets.
        1) The sheet piles shall be continuous and driven in interlock.
        2) If the bottom of the excavation is located below the water table, use "thumb and finger" type interlock.
    g. Not applying shoring loads to existing structures and other improvements.
    h. Not changing existing soil loading on existing structures and other improvements.
    i. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when the gap exceeds 1/2 inch before the wales are loaded.

1.05 SUBMITTALS

A. Shop drawings and calculations:
   1. For trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in. Submit in advance of excavation work, detailed drawings showing means for safe and stable excavations:
   2. Perform design pursuant to general engineering design practice.
   3. For excavations other than trenches, submit, in advance of excavation work, design calculations as performed pursuant to general engineering design practice, as specified in this Section, and detail drawing showing means for safe and stable excavations. In design calculations and detail drawing, cover, as a minimum:
      a. Excavations adjacent to structures and other improvements, and
      b. Excavations 5 feet or more in depth, or less than 5 feet in depth when there is potential for cave-in, at other locations.
   4. Submit following:
      a. Provide calculations for the different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by the shoring, and sequence of removal of shoring.
      b. Provide sketches showing the condition at various stages of installation and removal of shoring.
      c. Show structures, pipelines, and other improvements located near the shoring, and the shoring on a plan.
      d. When utilities penetrate the shoring, submit an elevation of all sides of the shoring showing the locations of the penetrations.
         1) Submit details on ground support and sealing around utility penetrations.

B. Written geotechnical report on soil characteristics and design recommendations, as specified in this Section.

C. Control points and schedule of measurements:
   1. Submit location and details of control points and method and schedule of measurements in accordance with requirements of this Section.
   2. Promptly upon constructing control points and making measurements at such control points, as specified in this Section, submit copy of field notes with such measurements.
      a. The field notes shall show the current measurement and the change in measurement from the first measurement taken.

D. Detailed sequence of installation and removal of shoring:
   1. Consider effects of ground settlement in the sequence of installation and removal of shoring.
   2. Provide sketches showing the conditions at various stages in the sequence of installation and removal of shoring.

E. Submit submittals for stability of excavations as a complete package and include all items required in this Section.
   1. Incomplete submittals will not be reviewed and will be returned for resubmittal as a complete package.

1.06 SEQUENCING AND SCHEDULING

A. Do not begin work on excavations, trenches, and means for providing stability of excavation and trenches until submittals have been accepted by Engineer and until materials necessary for installation are on site.

B. Submit submittals a minimum of 30 days prior to the scheduled date to begin excavation work.

C. Do not begin construction of any shoring or excavation operations until:
   1. Control points as specified in this Section and as indicated on the Drawings on existing structures and other improvements have been established and surveyed to document initial elevations and locations.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 INSTALLATION AND REMOVAL

A. Install means for providing safe and stable excavations as indicated in the submittals.

B. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of the Work.
   1. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating large voids and causing settlement.
   2. To prevent settlement caused by pulling shoring, fill voids with sand, pea gravel, or pressure injected grout.
   3. The methods used shall prevent settlement.
   4. Pressure preservative treated wood lagging may be left in place when acceptable to the Engineer.

3.02 MAINTENANCE

A. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.

B. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

3.03 CONTROL POINTS

A. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
   1. Set control points on shoring support system:
      a. Set points at distances not exceeding 25 feet at each support level.

b. Support levels shall be levels of tie-backs, wales, bottom of excavation, and other types of supports.

2. Set control points in corners of existing structures and on curbs, manholes, and other improvements indicated on the Drawings.

B. Provide plumb bobs with horizontal targets indicating original position of plumb bobs in relation to shoring at control points located on shoring.

C. Perform horizontal and vertical survey and measurement of control points at least once every week.

END OF SECTION

SECTION 02268

SOIL ANCHORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for soil anchors.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.
   2. A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   3. A 722 - Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete.
   4. A 775 - Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
   5. C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-Inch or [50-mm] Cube Specimens).

B. Post Tensioning Institute (PTI):
   1. Recommendations for Prestressed Rock and Soil Anchors.

1.03 SUBMITTALS

A. Product data: Submit detailed shop drawings showing the following:
   1. Anchor with the double corrosion protection system.
   2. Location, size, and length of anchor.
   3. Installation and testing procedures.

B. Samples: Submit the following samples and data:
   1. One 5-foot length of anchor having the double corrosion protection system.
   2. 1 complete stressing head assembly.
   3. Certified mill report for threadbar tendon.
   4. Certified mill report for stressing head assembly.
   5. Certification for factory-applied epoxy-coated ends.
   6. Certification for compressive and tensile strength of corrugated and smooth sheathing.

1.04 QUALITY ASSURANCE

A. Qualifications: Submit evidence that the foundation system’s contractor and anchor supplier have been engaged in the successful installation, supply, and testing of anchors for at least 5 years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Double corrosion protected anchors: Manufacturers: The following or equal:
   1. DYWIDAG Systems International.

2.02 MATERIALS

A. Each anchor shall consist of a single, deformed bar of prestressing steel encased in polyvinyl chloride corrugated sheathing. Pre-assemble and pre-grout the anchor at the factory prior to shipping to the jobsite.

B. The prestressing steel tendons shall be threaded bars, Grade 150 kilopounds per square inch in accordance with ASTM A 722, Type II, cold stretched and stress relieved after the threading process.

C. A smooth sheathing fitting snugly over the corrugated sheathing in the free stressing length shall guarantee unobstructed elongation during stressing.
   1. Center the deformed prestressing bar in the corrugated sheathing.
   2. Fill annular space between the bar and the sheathing with cement grout.

D. Form a gastight and watertight barrier around the prestressing steel bar.
   1. Use plastic sheathing resistant against chemical attack and aging.
   2. Use polyvinyl chloride corrugated plastic sheathing having a minimum compressive strength of 15,000 pounds per square inch and a minimum tensile strength of 7,000 pounds per square inch.
   3. Use material free of water, soluble chlorides, and other ingredients that might enhance corrosion, hydrogen embrittlement, or stress corrosion on the prestressing steel.
   4. The plastic shall be non-reactive with the grout and its ingredients.

E. Factory-apply epoxy coating in accordance with ASTM A 775 to the protruding bar exposed from the corrugated sheathing.

F. A steel seamless pipe (trumpet) welded to the steel bearing plate shall guarantee continuity of corrosion protection.
   1. Use sufficient length of seamless pipe to overlap the corrugated sheathing.
   2. Use steel bearing plates in accordance with ASTM A 36.

G. Fit a steel hexagonal nut into the countersunk hole in the bearing plate.
   1. Use heavy-duty type hexagonal nuts with round head, in accordance with ASTM A 325 or the bar manufacturer's specifications.
   2. Use factory-applied epoxy coating in accordance with ASTM A 775 on both the steel hexagonal nut and bearing plate with trumpet.

H. Encapsulate the hexagonal nut with a plastic cap and plastic nut filled with mastic corrosion inhibitor (grease) for corrosion protection.
   1. Use a mastic corrosion inhibitor that is waterproof, non-corrosive, non-hardening sealing compound grease for the stressing head assembly.

I. Use neat cement grout for grouting anchors with a water-cement ratio of 0.45 by weight.

1. Mix expanding agent additive with the grout that is acceptable to the Engineer.

J. The cement grout shall have sufficient strength to guarantee the load transfer between the threaded bar and the corrugated sheathing.
   1. Perform random sampling and testing of cement grout for test anchors as required by Engineer to verify strength.
   2. Use test procedure that is in accordance to ASTM C 109.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling:
   1. For rock anchors, use core drilling, rotary drilling, and percussion drilling. For soil anchors, augering or ramming may be employed as the conditions warrant.
      a. Use steel casing to the depth required to maintain an open hole.
   2. Drill the holes to the diameter, depth, line, and tolerances indicated on the Drawings.
   3. Drill the hole to a depth of 12 inches beyond the end of the anchor tendon.
      a. Drill the holes to an angle tolerance of 3 percent of their planned location.
      b. Drill the holes with a straightness such that in any section of hole 10 feet long, the maximum deviation from a straight line between the ends of the section shall not exceed 1.0 inches.
   4. Prior to installation of the anchor tendon, test the drill hole for watertightness by filling it with water and subjecting it to a pressure of 5 pounds per square inch.
      a. If, as determined by the Engineer, water loss over a period of 10 minutes is excessive, consolidation-grout the hole and re-drill and re-test the hole.
      b. If necessary, repeat this procedure until watertightness reaches a satisfactory level.
   5. Do not perform water tests where the water would affect the strength of the rock or the bond between grout and rock.

B. Anchor installation:
   1. Before installation of the anchor tendon, clean each hole of all debris and dust by a method acceptable to the Engineer.
   2. Supervise the installation and testing of the first 2 test anchors by a qualified representative of the manufacturer.
   3. Place anchor tendons in accordance with PTI Recommendations for Prestressed Rock and Soil Anchors and per manufacturer's shop drawing.
      a. Use equipment for placing so that it will not damage the corrugated sheathing.
   4. Grout the anchor bond length by injecting grout at the lowest point in the anchor.
      a. Use bonded and unbonded lengths as indicated on the Drawings.

3.02 FIELD QUALITY CONTROL

A. Tests:
   1. Anchor testing and stressing:
      a. Test each anchor.

b. Use a maximum test load that does not exceed 80 percent of the guaranteed ultimate tensile strength (GUTS) of the tendon.

2. Performance test:
   a. Performance test anchors per the manufacturer's written recommendations.
   b. Perform the performance test by incrementally loading and unloading the anchor in accordance with the following schedule.
   c. At each increment, record the movement of the tendon to the nearest 0.001 inch (0.0025 centimeter) with respect to an independent fixed reference point.
   d. Monitor jack load with a pressure gauge or load cell.
   e. The increment of load shall be: P = design load for the anchor; AL = alignment load.

Performance Test	
First Load Application	AL
Second Load Application	0.25P
Unload	
Third Load Application	AL
Fourth Load Application	0.25P
Fifth Load Application	0.50P
Unload	
Sixth Load Application	AL
Seventh Load Application	0.25P
Eighth Load Application	0.50P
Ninth Load Application	0.75P
Unload	
Tenth Load Application	AL
Eleventh Load Application	0.25P
Twelfth Load Application	0.50P
Thirteenth Load Application	0.75P
Fourteenth Load Application	1.00P
Unload	
Fifteenth Load Application	AL
Sixteenth Load Application	0.25P
Seventeenth Load Application	0.50P
Eighteenth Load Application	1.00P
Nineteenth Load Application	1.20P
Unload	
Twentieth Load Application	AL

Performance Test	
Twenty-First Load Application	0.25P
Twenty-Second Load Application	0.50P
Twenty-Third Load Application	1.00P
Twenty-fourth Load Application	1.20P
Twenty-Fifth Load Application	1.33P (Hold for Creep Test) Adjust to Transfer Load

f. Hold the test load for 10 minutes. Record the total movements with respect to a fixed reference point at 1, 2, 3, 4, 5, 6, and 10 minutes.
g. If the total movement between 1 minute and 10 minutes exceeds 0.04 inches, hold the test load for an additional 50 minutes.
h. Total movements shall be recorded at 15, 20, 25, 30, 45, and 60 minutes.

3. Proof test: Proof test all production anchors.
   a. Perform the proof test by incrementally loading the anchor in accordance with the following schedule.
      1) At each increment, record the movement of the tendon to the nearest 0.001 inch with respect to an independent fixed reference point.
   b. Monitor the jack load with a pressure gauge or load cell.
   c. The increments of load shall be: P = design load for the anchor.

Proof Test
0
0.25P
0.50P
0.75P
1.00P
1.20P

4. Test load adjust to transfer load.
   a. Compare the proof test results to the performance test results.
   b. Any significant variation from the performance test results shall warrant making a performance test on the next anchor.
5. Acceptance criteria: The Engineer will investigate the anchor test results and determine whether the anchor is acceptable. An anchor will be acceptable if:
   a. The total elastic movement obtained from a performance test exceeds 80 percent of the theoretical elastic elongation of the stressing length and be less than the theoretical elastic elongation of the stressing length plus 50 percent of the bond length.
   b. The creep movement does not exceed 0.080 inches during the final time increment of the performance test regardless of tendon length and load.
   c. The lift-off test shows an anchor load within 10 percent of the specified transfer load.
   d. The Engineer will determine whether an anchor that fails to meet the above minimum acceptance criteria may be incorporated in the Work.
   e. Remove anchors that are not accepted by the Engineer.

1) Fill holes left from anchor removal with 95 percent compacted engineered fill.

END OF SECTION

SECTION 02280

SUBSURFACE UTILITY ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Requirements for subsurface utility engineering (SUE) as part of the WORK for new pipelines.

B. Related section:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Document 0800 - Supplementary Conditions.
      b. Section 01140 - Work Restrictions.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 38-02 Standard Guideline for the Collection and Depiction of Existing and Subsurface Utility Data.

1.03 DEFINITIONS

A. General: Definitions used in this Section are in accordance with ASCE 38 02.

1.04 REQUIREMENTS

A. Existing utilities indicated on the Drawings are approximately only and are provided based on the best information available by use of reports listed in Document 0800

B. Existing utilities are shown for the convenience of Contractor only.
   1. It is the Contractor's responsibility to field verify the vertical and horizontal location of all utilities including those not indicated or incorrectly indicated on the Drawings.

C. Contractor is responsible to review all geotechnical reports, record drawings, and Contract Documents.

D. Coordinate with utility locator, such as CALL BEFORE YOU DIG, and other affected entities.

E. Contractor is responsible for protecting all utilities encountered.

1. Before any excavation, follow requirements of Section 01140.
2. If a conflict exists between what is indicated on the Drawings and what exists in the field, Contractor shall notify Engineer immediately.

F. Where scheduled, provide subsurface utility engineering services by a Civil Engineer registered in the state the project is located in accordance with ASCE 38-02.

G. Requirements: The SUE shall entail the following at a minimum:
1. Review of existing record drawings.
2. Geophysical methods such as ground penetrating radar.
3. Soft excavation to locate known utilities along the proposed pipeline alignment.
4. Open trench excavation to locate unknown utilities along the proposed pipeline alignment.
5. Utilization of field survey by a Professional Land Survey licensed in the state the project is located in for determination of vertical and horizontal locations.

1.05 QUALIFICATIONS

A. General: Contractor shall utilize the services of a qualified subconsultant for SUE services with minimum qualifications that include but are not limited to:
1. Minimum of 5 years of SUE experience in the state the project is located in where providing vertical and horizontal locations of utilities in accordance with ASCE 38-02 utility quality level A was required.
2. Completion of 5 SUE projects of equal or greater magnitude within the past 5 years.

1.06 SUBMITTALS

A. Shop Drawings:
1. Contractor shall submit all SUE information as follows:
   a. Plan drawings that clearly illustrates vertical and horizontal location of known and unknown utilities.
      1) Horizontal location shall include northing and easting coordinates.
   b. Identifies size and material and service for known utilities.
   c. Identify size and material for unknown utilities.
2. Review of shop drawings and calculations by Engineer and Owner are for record only.
3. Drawings shall be performed, stamped, and endorsed by a Civil Engineer registered in the state the project is located.
4. Field survey information shall be performed, stamped and endorsed by a Surveyor registered in the state the project is located in.

B. Detailed sequence of SUE:
1. Submit a schedule for all SUE events that shows start, end and intermediate milestones.
2. Provide sketches showing the conditions at various stages in the sequence of SUE.

C. Submit submittals for stability of excavations as a complete package and include all items required in this Section.
1. Incomplete submittals will not be reviewed and will be returned for resubmittal as a complete package.

1.07 SEQUENCING AND SCHEDULING

A. Coordinate all WORK with restrictions provided in Section 01140.

B. Do not begin WORK until submittals have been accepted by Engineer and until equipment and materials necessary for installation are on site.

C. Submit submittals a minimum of 30 days prior to the scheduled date to begin excavation work.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 SUE SCHEDULE

A. Provide SUE services for the following pipelines and utilities.

Description	Reference Drawings
18 inch Low Pressure Air to Aeration Basin No. 1	0C14
20 inch Low Pressure Air to Aeration Basin No. 2	0C14
20 inch Low Pressure Air to Aeration Basin No. 3	0C12
18 inch Stormwater	0C15, 0C16, 0C17, 0C18
8 inch Potable Water	0C15, 0C17
6 inch Potable Water	0C15
30” Final Effluent	0C15
Electrical Ductbank	0E04, 0E05

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Refer to the project Geotechnical Report. This section summarized geotechnical recommendations but shall not be considered a substitute for the Geotechnical Report. If this section conflicts with the Geotechnical Report, the Report shall govern.

B. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
   2. Backfilling and compacting under and around structures.

C. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01500 - Temporary Facilities and Controls.
      b. Section 02050 - Basic Site Materials and Methods.
      c. Section 02238 - Rock Removal.
      d. Section 02312 - Controlled Low Strength Material (CLSM).
      e. Section 02722 - Aggregate Base Courses.
      f. Section 03300 - Cast-In-Place Concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.
   2. D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
   3. D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
   4. D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.03 DEFINITIONS

A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

B. Embankments: Dikes, levees, berms, and similar facilities.

C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Where mud or other soft or unstable material is encountered, remove such material, allow to dry to near optimum moisture (+/- 2%), and recompact. In place of drying wet soils, chemical stabilization per MAG Standard Specification 311 may be followed.
   2. Obtain acceptable import material from other sources if surplus or borrow materials obtained within Project site do not conform to specified requirements or are not sufficient in quantity.
   3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

1.05 SUBMITTALS

A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.

B. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.

C. Test reports:
   1. Submit certified test reports of all tests specified to be performed by the Contractor.
   2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering licensed in Arizona.

D. Plan for mitigating existing drainage swale at north end of site during construction.

1.06 QUALITY ASSURANCE

A. Excavation:
   1. If seepage from the slopes is encountered during excavation, the Engineer should be notified.

B. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 25 cubic yards of backfill adjacent to structures.

b. 50 cubic yards of embankment work.
c. 50 cubic yards of select native fill material.
d. 25 cubic yards of roadway base material.
e. 25 cubic yards of non-expansive select fill material.

2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."

C. Drainage:
1. Positive drainage away from structures and controlled routing of runoff should be maintained to prevent ponding or infiltration adjacent to structures.

1.07 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 MATERIALS

A. Water for compacting: As specified in Section 01500.

B. Soil and rock materials:
1. General:
a. Provide aggregate base course, controlled low strength material, drain rock, native material, sand, select native material, and drain rock where specified or indicated on the Drawings.
b. If suitable surplus materials are available, obtain native material and select native material from cut sections or excavations.
2. Aggregate base course materials: As specified in Section 02722.
3. Gravel: As specified in Section 02050.
4. Select native material: As specified in Section 02050.
5. Sand: As specified in Section 02050.
6. Select Material: As specified in Section 02050.

C. Controlled low strength material (CLSM): As specified in Section 02312.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:

1. Character and quantity of material:
    a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
    b. Determine gradation and shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
    c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations, borrow areas or imported materials. Include in cost of work to be performed.
    d. Include wasting of excess material, if required, in cost of work to be performed.

3.02 PREPARATION

A. Backfills:
1. After clearing, demolition, and over-excavation as indicated on the Drawings are completed, scarify entire areas which underlie backfills or structures to a depth of 8 inches and until surface is free of ruts, hummocks, and other features which would prevent uniform compaction by equipment to be used.
2. Moisture condition subgrade to optimum (±2 percent) and compact to at least 95 percent (slabs on grade and fills less than 5 ft below finished grade) and 97 percent (fill greater than 5 feet below finished grades and/or footing bottom) of maximum dry density as determined by ASTM D-698. Recompact scarified areas to density specified before placing backfill material or concrete.
3. If foundation areas have soft saturated soils, remove soils and dry back to near optimum and recompact. Should the Contractor not have time to allow soils to dry, alternative options could include mixing with either a chemical lime slurry or dry cement. Remove all loose material as directed by the Engineer. Do not remold and weaken the remaining soil by operating heavy equipment on final bottom elevation of excavation.
4. Do not place backfill against walls or grade beams until:
    a. Walls or grade beams have been cast full height of structure and concrete has reached the specified strength.
    b. Connecting slabs have been cast and concrete has reached the specified strength.
5. Prior to backfilling:
    a. Remove all forms.
    b. Clean all trash and debris from the excavation site.
6. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:
1. After clearing is completed, scarify entire areas which underlie embankments to a depth of 8 inches and until surface is free of ruts, hummocks, and other features which would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for embankments before placing of embankment material.
3. If embankment areas have cemented rock, cobbles, or boulders, do not scarify the top 8 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.

C. Fills:

1. After clearing is completed, scarify entire areas which underlie fill sections or structures to a depth of 8 inches and until surface is free of ruts, hummocks, and other features which would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.
3. If fill areas have cemented rock, cobbles, or boulders, do not scarify the top 8 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.

D. Roadway fills:
1. After clearing is completed, scarify entire areas which underlie roadway fills to a depth of 8 inches and until surface is free of ruts, hummocks, and other features which would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.
3. If roadway fill areas have cemented rock, cobbles, or boulders, do not scarify the top 8 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.

E. Sloped surfaces for fill or foundations:
1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
   a. Bench or terrace to adequately key existing ground and fill built thereon.
2. Provision of new benches:
   a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
   b. Recompact material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

A. General:
1. Dispose of excavated materials which are not required or are unsuitable for fill and backfill in lawful manner.
2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
3. Obtain material required in excess of suitable material produced by cuts and excavation, from borrow areas subject to the material requirements specified.
4. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from Project site at no additional cost to Owner.
5. Stabilization of subgrade: If directed by Engineer, provide materials used, or perform work required, to stabilize subgrade so it can withstand loads which may be placed upon it by Contractor’s equipment.

B. Borrow area:
1. On site borrow areas have been listed on the Drawings.

C. Compaction:
1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.

2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D 1556, or with ASTM D 2922 and ASTM D 3017.
4. Maximum density obtained in laboratory when tested in accordance with ASTM D 698.
5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
6. Compact to percentage of maximum density per ASTM D-698 as follows:
    a. Backfill adjacent to structures: 95 percent (fills < 5 feet below F.G.); 97 percent (fills > 5 feet below F.G.).
    b. Backfilling voids: 95 percent.
    c. Below slabs-on-grade: 95 percent.
    d. Embankments/berms: 95 percent.
    e. Aggregate base course: 95 (below slabs); 100 (below asphalt).
    f. Loose fill:
        1) No compaction other than by hauling vehicles will be required.
        2) Uniformly distribute travel of vehicles over fill area as required to provide uniformly compacted surface.
    g. Under parking areas: 100 percent.
    h. Upper 6 inches of cuts: 95 percent.
    i. Trench backfill:
        1) See Specification Section 02318.

D. Excavation:
1. Blasting: Not permitted.
2. Excavations for structures:
    a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure, including trenching for piping and all work incidental thereto.
    b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
    c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
    d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
        1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
        2) Under footings: Restore to the proper elevation using one of the following:
            a) Aggregate base-course.
            b) Controlled low strength material.

e. Excavation width:
1) Extend excavations as indicated on the Drawings, but at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
2) Do not undercut slopes.
f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.

3. Necessary over excavation:
a. Over excavate below slabs on grade to elevations indicated on the Drawings.
b. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
c. As an alternative to removing and allowing soft, wet soils to dry, soils can be chemically stabilized with lime or cement per MAG Specification 311.
d. Backfill voids with material acceptable to the Engineer:
1) With acceptance of the Engineer, backfill with one of the following:
a) Aggregate base course.
b) Controlled low strength material.

E. Materials for backfills, embankments, fills, roadway fills:
1. General:
a. Obtain import material from other sources if on-site borrow areas do not conform to specified requirements or are not sufficient in quantity for construction of Project.
2. Backfills:
a. Backfill adjacent to structures, slabs, or walls: Select native material, or imported material meeting the requirements of select native material unless otherwise specified or indicated on the Drawings.
b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low strength material or concrete encasement are indicated on the Drawings.

3. Embankments/berms:
a. Native material, or imported material meeting the requirements of native material unless otherwise specified or indicated on the Drawings.
4. Fills:
a. Native material, or imported material meeting the requirements of native material unless otherwise specified or indicated on the Drawings.
5. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
a. Aggregate base course material.

F. Placement:
1. General:
a. Lines and grades:
1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
2. Backfills:

a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting (optimum moisture content ±2 percent for fill outside of slabs/structures).
c. Defective compacted backfills: Remove and recompact.

3. Fills:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
   b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting (optimum moisture content ±2 percent for fill outside of slabs/structures).
   c. Defective compacted fills: Remove and recompact.
4. Coarse fill:
   a. When materials are coarsely graded so that performance of field density tests are impossible:
      1) Placement and compaction: Place material in lifts so as to obtain compacted thickness of 6 inches and roll with pneumatic roller or power roller.
      2) Moisture content: Provide moisture content of fraction of material passing 3/4 inch sieve within plus or minus 2.0 percent of optimum moisture as determined in accordance with ASTM D 1557, Method C.
5. Embankments/berms:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
   b. Bring each layer to -2%/+3% of optimum moisture content before compacting.
   c. Defective compacted embankments: Remove and recompact.
6. Roadway fills:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction:
   b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
   c. Defective compacted roadway fills: Remove and recompact.

3.04 FIELD QUALITY CONTROL

A. Tests:
   1. Confirmation tests:
      a. Contractor's responsibilities:
         1) Accomplish specified compaction for backfills, fills, and other earthwork.
         2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
         3) Cost of confirmation tests: Paid for by the Contractor.
         4) Qualifications of Contractor's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the Engineer.
         5) Copies of confirmation test reports: Submit promptly to the Engineer.
      b. Frequency of confirmation testing:
         1) Perform testing not less than the following:

a) In-place density:
(1) Backfill under slabs and walls: 1 every 50 cubic yards.
(2) Subgrade: every 3,000 square feet.
(3) Embankments: 1 every 200 cubic yards.
(4) Fills: 1 every 200 cubic yards.
(5) Roadway fills: 1 every 100 cubic yards.
b) Maximum dry density versus moisture:
(1) Backfill under slabs and walls: 1 every 100 cubic yards.
(2) Subgrade: 1 every 6,000 square feet.
(3) Embankments: 1 every 400 cubic yards.
(4) Fills: 1 every 400 cubic yards.
(5) Roadway fills: 1 every 200 cubic yards.

2. Compliance tests:
   a. Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
   b. Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
   c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
      1) Remove and replace materials at proper density.
      2) Bring density up to specified level by other means acceptable to the Engineer.
   d. Retesting:
      1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
      2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.

B. Tolerances:
1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
   a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
   b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
2. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
   a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
   b. Intent of proceeding is to avoid sandy or gravelly areas.
3. Finish grading of surfaces:
   a. Reasonably smooth, compacted, and free from irregular surface changes.
   b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
   c. Uniformly grade areas which are not under concrete.
   d. Finish ditches and gutters so that they drain readily.

3.05 ADJUSTING

A. Finish grades of excavations, backfills, and fills:

1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:
   1. Protect newly graded areas from erosion and deterioration by action of the elements.

B. Ditches and gutters:
   1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 02312

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controlled low strength material (CLSM).

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03300 - Cast-in-Place Concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   2. C 33 - Standard Specification for Concrete Aggregates.
   3. C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   4. C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
   5. C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   6. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   7. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   8. D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700 kN-m/m^3)).

1.03 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Total calculated air content: Not be less than 8.0 percent nor greater than 12.0 percent.
   2. Minimum unconfined compressive strength: Not less than 50 pounds per square inch measured at 28 days.
   3. Maximum unconfined compressive strength: Not greater than 150 pounds per square inch measured at 28 days.
   4. Wet density: No greater than 132 pounds per cubic foot.

1.04 SUBMITTALS

A. Product data: Submit data completely describing products.

B. Sieve analysis: Submit sieve analyses of fine and coarse aggregates being used in triplicate. Resubmit at any time there is a significant change in grading of materials.

C. Mix: Submit full details, including mix design calculations for mix proposed for use.

D. Trial batch test data:
   1. Submit data for each test cylinder.
   2. Submit data that identifies mix and slump for each test cylinder.

E. Cement mill tests: Include alkali content, representative of each shipment of cement for verification of compliance with specified requirements.

F. Pozzolan certificate of compliance: Identify source of pozzolan and certify compliance with requirements of ASTM C 618.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland cement: Type II low alkali portland cement as specified in Section 03300.

B. Fly ash: Class F fly ash in accordance with ASTM C 618.

C. Water: As specified in Section 03300.

D. Admixture: Air entraining admixture in accordance with ASTM C 260.

E. Fine aggregate: Concrete sand that does not need to be in accordance with ASTM C 33. No more than 12 percent of fine aggregate shall pass a No. 200 sieve, and no plastic fines shall be present.

F. Coarse aggregate: Pea gravel no larger than 3/8 inch.

2.02 MIXES

A. Suggested design mix:

Material	Weight	Specific Gravity	Absolute Volume Cubic Foot
Cement	30 pounds	3.15	0.15
Fly Ash	300 pounds	2.30	2.09
Water	283 pounds	1.00	4.54
Coarse Aggregate	1,465 pounds	2.68	8.76
Fine Aggregate	1,465 pounds	2.68	8.76
Admixture	4-6 ounces	-	2.70
TOTAL	3,543 pounds	-	27.00

2.03 SOURCE QUALITY CONTROL

A. Trial batch:
   1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
   2. Prepare trial batches using specified cementitious materials and aggregates proposed to be used for the Work.
   3. Prepare trial batch with sufficient quantity to determine slump, workability, consistency, and to provide sufficient test cylinders.

B. Test cylinders:
   1. Prepare test cylinders in accordance with ASTM C 31 with the following exceptions:
      a. Fill the concrete test cylinders to overflowing and tap sides lightly to settle the mix.
      b. Do not rod the concrete mix.
      c. Strike off the excess material.
   2. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
   3. Do not remove the test cylinder from mold until the cylinder is to be capped and tested.
   4. The test cylinders may be capped with standard sulfur compound or neoprene pads:
      a. Perform the capping carefully to prevent premature fractures.
      b. Use neoprene pads a minimum of 1/2 inch thick, and 1/2 inch larger in diameter than the test cylinders.
      c. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.

C. Compression test 8 test cylinders: Test 4 test cylinders at 3 days and 4 at 28 days in accordance with ASTM C 39 except as modified herein:
   1. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.

D. If the trial batch tests do not meet the Specifications for strength or density, revise and resubmit the mix design, and prepare additional trial batch and tests. Repeat until an acceptable trial batch is produced that meets the Specifications.
   1. All the trial batches and acceptability of materials shall be paid by the Contractor.
   2. After acceptance, do not change the mix design without submitting a new mix design, trail batches, and test information.

E. Determine slump in accordance with ASTM C 143 with the following exceptions:
   1. Do not rod the concrete material.
   2. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.

PART 3 EXECUTION

3.01 INSTALLATION

A. Prior to placement, soils located below controlled low strength material placement shall be scarified to a depth of 8 inches, uniform moisture conditioned to or above the optimum moisture content, and compacted to a minimum of 95 percent relative compaction in accordance with ASTM D 1557.

B. Place controlled low strength material by any method which preserves the quality of the material in terms of compressive strength and density:
   1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent lateral load due to the weight of the next lift of CLSM.
   2. The basic requirement for placement equipment and placement methods is the maintenance of its fluid properties.
   3. Transport and place material so that it flows easily around, beneath, or through walls, pipes, conduits, or other structures.
   4. Use a slump of the placed material greater than 9 inches, and sufficient to allow the material to flow freely during placement:
      a. After trial batch testing and acceptance, maintain slump developed during testing during construction at all times within plus or minus 1 inch.
   5. Use a slump, consistency, workability, flow characteristics, and pumpability (where required) such that when placed, the material is self-compacting, self-densifying, and has sufficient plasticity that compaction or mechanical vibration is not required.

3.02 FIELD QUALITY CONTROL

A. General:
   1. Make provisions for and furnish all material for the test specimens, and provide manual assistance to assist the Engineer in preparing said specimens.
   2. Be responsible for the care of and providing curing condition for the test specimens.

B. Tests by Owner:
   1. During the progress of construction, the Owner will have tests made to determine whether the controlled low strength material, as being produced, complies with the requirements specified hereinbefore. Test cylinders will be made and delivered to the laboratory by the Engineer and the testing expense will be borne by the Owner.
   2. Test cylinders:
      a. Prepare test cylinders in accordance with ASTM C 31 with the following exceptions:
         1) Fill the concrete test cylinders to overflowing and tap sides lightly to settle the mix.
         2) Do not rod the concrete mix.
         3) Strike off the excess material.

b. Place the cylinders in a safe location away from the construction activities. Keep the cylinders moist by covering with wet burlap, or equivalent. Do not sprinkle water directly on the cylinders.
c. After 2 days, place the cylinders in a protective container for transport to the laboratory for testing. The concrete test cylinders are fragile and shall be handled carefully. The container may be a box with a Styrofoam or similar lining that will limit the jarring and bumping of the cylinders.
d. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
e. Do not remove the test cylinder from mold until the cylinder is to be capped and tested.
f. The test cylinders may be capped with standard sulfur compound or neoprene pads:
    1) Perform the capping carefully to prevent premature fractures.
    2) Use neoprene pads a minimum of 1/2 inch thick, and 1/2 inch larger in diameter than the test cylinders.
    3) Do not perform initial compression test until the cylinders reach a minimum age of 3 days.

3. Not less than 3 cylinder specimens will be tested for each 150 cubic yards of controlled low strength material and not less than 3 specimens for each half day's placement:
    a. Test 1 cylinder at 3 days and 2 at 28 days in accordance with ASTM C 39 except as modified herein.
    b. The compression strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
4. The Owner will test the air content of the controlled low strength material. Test will be made immediately after discharge from the mixer in accordance with ASTM C 231.

C. Tests by Contractor:
1. Test the slump of controlled low strength material using a slump cone in accordance with ASTM C 143 with the following exceptions:
    a. Do not rod the concrete material.
    b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
2. Test the slump at the beginning of each placement, as often as necessary to keep the slump within the specified range, and when requested to do so by the Engineer.

END OF SECTION

SECTION 02318

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Trench excavation, fine grading, pipe bedding, backfilling, and compaction for the following, including requirements for ditch crossings:
   1. Pipes.
   2. Direct buried electrical and control conduits.
   3. Electrical and control duct banks.
   4. Manholes, valves, or other accessories.
   5. Potable water pipe appurtenances.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02050 - Soils and Aggregates for Earthwork.
      b. Section 02240 - Dewatering.
      c. Section 02260 - Excavation Support and Protection.
      d. Section 02300 - Earthwork.
      e. Section 02312 - Controlled Low Strength Material (CLSM).
      f. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
   2. D 1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   3. D 6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 SUBMITTALS

A. Lab certification.

B. Confirmation test reports.

1.04 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 200 linear feet of trench backfill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."

PART 2 PRODUCTS

2.01 MATERIALS

A. Soil and rock materials:
   1. Aggregate base course material: As specified in Section 02050.
   2. Gravel: As specified in Section 02050.
   3. Native material: As specified in Section 02050.
   4. Sand: As specified in Section 02050.
   5. Select material: As specified in Section 02050.

B. Controlled low-strength material: As specified in Section 02312

PART 3 EXECUTION

3.01 PREPARATION

A. General:
   1. Embankment condition:
      a. Exists where width of trench exceeds limits specified in this Section.
      b. Before laying pipes in fill, place fill and compact it to not less than 2 feet above top of pipe.
      c. After placing and compacting fill, excavate pipe trench through fill.

B. Protection: Stabilize trench excavations as specified in Section 02260.

3.02 INSTALLATION

A. Trench excavation:
   1. General requirements:
      a. If, because of soil conditions, safety requirements, or other reasons, trench width at top of pipe is increased beyond width specified in this Section, upgrade laying conditions or install stronger pipe designed in conformance with Specifications for increased trench width, without additional cost to Owner.
      b. Excavate bottom of trench to depth indicated on the Drawings. The bottom of the trench excavation shall be firm and dry.

2. The trench may be excavated by machinery to the grade indicated on the Drawings provided that the soil material remaining in the bottom of the trench is no more than slightly disturbed. Scarify and recompact bottom of trench: Scarify bottom of trench to a depth of 6 inches. Recompact scarified material to 95 percent of maximum density.
3. Rock:
    a. Pipe: If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of fine grading material. Backfill overcut with aggregate base course material compacted to 95 percent of maximum density up to bottom of fine grading material.
    b. Direct buried electrical and control conduits: If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of conduit bedding material. Backfill overcut with aggregate base course material up to bottom of conduit bedding material.
    c. Electrical and control ductbanks: If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of concrete ductbank. Backfill overcut with aggregate base course material up to bottom of concrete ductbank.
4. Overcut of trench bottom: Where the bottom of the trench is excavated below the depth indicated on the Drawings, restore trench bottom to proper grade by back filling with aggregate base course material compacted to 95 percent of maximum density, at no additional cost to Owner.
5. Soft or unstable material:
    a. If bottom of excavation is found to consist of soft or unstable material which is incapable of providing proper support, remove such material to a depth and for the length required, as determined by the Engineer. Backfill trench to bottom of fine grading material with aggregate base course material compacted to 90 percent of maximum density.
6. Concrete cradle: Where indicated on the Drawings, cradle pipe in concrete.
7. Trench widths:
    a. Minimum clear width of trench for pipe (measured at top of pipe):
        1) For pipe sizes 4 inches to and including 24 inches: Not less than outside diameter of pipe plus 18 inches.
        2) For pipe sizes larger than 24 inches: Not less than outside diameter of pipe plus 24 inches.
    b. Maximum clear width of trench for pipe (measured at top of pipe):
        1) For pipe sizes 4 inches to and including 24 inches: Not to exceed outside diameter of pipe plus 24 inches.
        2) For pipe sizes larger than 24 inches: Not to exceed outside diameter of pipe plus 36 inches.
8. For manholes, valves, or other accessories:
    a. Provide excavations sufficient to leave at least 12 inches clear between their outer surfaces and sides of trench or shoring.
    b. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

c. Backfill under manholes, vaults, tanks, or valves with aggregate base course material. Do not backfill with soil.
d. Fill any unauthorized excess excavation below elevation indicated on the Drawings for foundation of any structure with aggregate base course material at no additional cost to Owner.

9. Potable water pipe appurtenances:
   a. Lay in trenches separate from those used for sewers.
   b. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.
10. At road crossings or existing driveways:
   a. Make provision for trench crossings at these points, either by means of backfills, tunnels, or temporary bridges.

B. Dewatering: As specified in Section 02240.

C. Pipe fine grading:
1. Schedule fine grading material as specified in this Section.
2. For pipes 16 inches in nominal diameter and under.
   a. Place 4 inches of fine grading material below bottom of pipe.
   b. Place fine grading material at uniform density, with minimum possible compaction.
3. For pipe over 16 inches in diameter.
   a. Place 4 inches, or 1/12 the outside diameter of pipe, whichever is greater, of fine grading material below bottom of pipe.
   b. Place fine grading material at uniform density, with minimum possible compaction.
4. Bell or coupling holes:
   a. Dig holes after trench bottom has been graded.
   b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding.
   c. Excavate holes only as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
5. Depressions for joints, other than bell-and-spigot:
   a. Make in accordance with recommendations of joint manufacturer for particular joint used.

D. Pipe bedding:
1. Schedule bedding material as specified in this Section.
2. After pipe laid:
   a. Place bedding material under and around pipe in 6 inch maximum lifts of bedding material, to level 12 inches above top of pipe. Compact to 90 percent of maximum density.
3. Pipe displacement:
   a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
   b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.

E. Trench backfill above pipe bedding, electrical and control conduit bedding, and electrical and control ductbanks:
   1. Under structures:
      a. Backfill trench up to underside of structure with aggregate base course material as specified in Section 02050 compacted to 95 percent of maximum density.
   2. Cuts across roadways and paved streets:
      a. Backfill trench to underside of pavement with aggregate base course material as specified in Section 02050 compacted to 95 percent of maximum density.
   3. Under and parallel to roadways, paved areas, or storage areas:
      a. Backfill trench up to within 2 feet of finish grade with select material as specified in Section 02050 compacted to 95 percent of maximum density.
      b. Then backfill from 2 feet below finish grade to finish grade, or underside of aggregate base course or pavement as indicated on the Drawings with aggregate base course material as specified in Section 02050, compacted to 95 percent of maximum density.
   4. In areas outside the improved section of roadways or in open country:
      a. Backfill to finish grade with native material as specified in Section 02050 compacted to 90 percent of maximum density.
   5. Through earth slopes adjacent to, or supporting structures:
      a. Backfill to finish grade with aggregate base course material or select material compacted to 95 percent of maximum density.

F. Under existing intersecting pipes or conduits larger than 3 inches in diameter:
   1. Backfill from bottom of new pipe trench to spring line of intersecting pipe or conduit with aggregate base course material, as specified in Section 02050, compacted to 90 percent of maximum density.
   2. Extend aggregate base course material as specified in Section 02050 two feet on either side of intersecting pipe or conduit to ensure that material remains in place while other backfill is being placed.
   3. Backfill remainder of trench as specified in “Trench backfill above pipe bedding and for conduits and duckbanks” above.

G. Compaction:
   1. In-place density of compacted trench backfill, and bedding determined in accordance with ASTM D 1556, or with ASTM D 6938.
   2. Maximum density obtained in laboratory when tested in accordance with ASTM D 1557.
   3. Consolidation:
      a. Do not use water settling methods such as flooding, poling, or jetting.
   4. Consolidation:
      a. When acceptable to the Engineer, perform consolidation by flooding and poling, or jetting so as to obtain compaction of backfill material at least equal to that specified.
      b. Do not use water settling methods when backfill material is not sufficiently granular in nature to be self-draining during and after consolidation and when foundation materials may be softened or otherwise damaged by water.
      c. When flooding, poling, or jetting methods are used, place and consolidate material used as backfill in layers not exceeding 4 feet in thickness.

d. Supplement flooding, poling, or jetting methods by use of vibratory or other compaction equipment when necessary to obtain required compaction.

H. Excess material:
1. Remove excess excavated material from the Project site as specified in Section 02300 and dispose of legally off site.

3.03 FIELD QUALITY CONTROL

A. Tests:
1. Confirmation tests:
a. Contractor's responsibilities:
1) Accomplish specified compaction of trench backfill.
2) Control operations by confirmation tests to verify and confirm that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
3) Cost of confirmation tests: Paid for by the Contractor.
4) Qualifications of Contractor's testing laboratory: Acceptable to Engineer. Provide lab certification.
5) Copies of confirmation test reports: Submit promptly to the Engineer.
b. Frequency of confirmation testing:
1) Perform testing not less than as follows:
a) For trenches: At each test location include tests for each type or class of backfill from bedding to finish grade.
b) In open fields: 2 every 1,000 linear feet.
c) Along dirt or gravel road or off traveled right-of-way: 2 every 500 linear feet.
d) Crossing paved roads: 2 locations along each crossing.
e) Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
2. Compliance tests:
a. Frequency of testing: Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
b. For tests in water settled backfill: Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
c. If compaction fails to meet specified requirements: Perform remedial work by one of the following methods:
1) Remove and replace backfill at proper density.
2) Bring density up to specified level by other means acceptable to the Engineer.
3. Retesting:
a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
b. Contractor's confirmation tests during performance of remedial work:
1) Performance: Perform tests in manner acceptable to the Engineer.
2) Frequency: Double amount specified for initial confirmation tests.

B. Piping system testing:
   1. As specified in Section 15956.

3.04 SCHEDULES

A. Pipe fine grading materials:
   1. Fine grading material shall be the same as bedding material.

B. Bedding materials:
   1. Pipes:
      a. For pipe less than 16-inch nominal size: Except as otherwise specified, use sand or aggregate base course material.
      b. For pipe from 16- inch to 48-inch nominal size: Except as otherwise specified, use sand or aggregate base course material.
      c. For pipe over 48 inches: Aggregate base course material.
      d. For polyvinyl chloride or other plastic pipe less than 2 inches in diameter: Sand.
   2. Direct buried electrical and control conduits: Sand.

END OF SECTION

SECTION 02362

TERMITE CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pre-construction application of termiticide for control of termite infestations in and around structures and construction.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01500 - Temporary Facilities and Controls.

1.02 REFERENCES

A. State of California - Business and Professions Code, Division 3.
   1. Chapter 14 - Structural Pest Control Operators.

B. United States Environmental Protection Agency (EPA):
   1. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

1.03 SUBMITTALS

A. Product data:
   1. Include for each toxicant to be used, composition by percentage, dilution schedule, rate and volume calculations, intended application rate.
   2. Current EPA-approved labels and Material Safety Data Sheets for each product used.

B. Manufacturer's instructions: Complete handling, mixing, application, cleanup, and safety instructions.

C. Project record documents: Accurately record quantity of product applied (concentrate), number of gallons of mixed emulsion applied, number of square feet treated, number of linear feet (and depth) of vertical barriers treated, use of vapor barrier after treatment, type of fill material used, and rate of application depending on type of fill material.

1.04 QUALITY ASSURANCE

A. Applicator qualifications:
   1. Company specializing in application of termiticide.
   2. Licensed by state where Project is located.

B. Regulatory requirements:
   1. Products bear EPA registration numbers under Federal Insecticide, FIRFA.
   2. Conform to applicable code in compliance with state and local regulations.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store in cool, dry, well-ventilated place. Do not store below 40 degrees Fahrenheit.

B. Do not store products on Project site unless locked in storage space meeting regulatory requirements.

C. Remove unused and waste materials in accordance with appropriate regulations.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. One of the following or equal:
   1. Pest Control Specialties Operations, Princeton, NJ.

2.02 MATERIALS

A. Dragnet(R) FT: Termiticide containing permethrin at rate of 3.2 pounds per gallon. EPA assigned "Signal Word" CAUTION.

B. Prevail(R) FT: Termiticide containing cypermethrin at rate of 2.0 pounds per gallon. EPA assigned "Signal Word" CAUTION.

2.03 MIX

A. Permethrin: 1.0 percent emulsion, add 2.5 gallons of Dragnet(R) FT to 97.5 gallons of water.

B. Cypermethrin: 0.6 percent emulsion, add 2.5 gallons of Prevail(R) FT to 97.5 gallons of water.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that soil surfaces are unfrozen, sufficiently dry to absorb toxicant, and ready to receive treatment.

B. Insure that area is well ventilated.

3.02 PREPARATION

A. Remove non-essential wood and cellulose containing material from around foundation walls, crawl spaces, and porches.

B. Repair faulty plumbing and construction grade to eliminate termite access to moisture.

C. Refer to manufacturer's instructions on package label.

D. Mix products with water to produce emulsions on job site.

3.03 APPLICATION

A. Apply in accordance with manufacturer's instructions.

B. Ensure that weather conditions comply with label recommendations prior to application.

C. Remove and handle termiticide containers per label instructions after application.

D. Re-treat as directed by Engineer.

3.04 PROTECTION

A. Protect finished work as specified in Section 01500.

B. Cover treated soil with waterproof barrier when slab will not be poured same day as treatment.

C. Keep personnel off of treated area until completely dry.

D. Avoid ditching, trenching, or movement of treated soil after application.

E. Re-treat area when movement of treated soil is required.

END OF SECTION

SECTION 02370

RIPRAP AND GABIONS EROSION AND SEDIMENTATION CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plain, and grouted riprap.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 90 - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
   2. C 150 - Standard Specification for Portland Cement.

1.03 SUBMITTALS

A. Product data.

B. Installation instructions.

PART 2 PRODUCTS

2.01 PLAIN RIPRAP

A. Material: Rock, broken concrete from site preparations, or wasted concrete from project pours.

B. Size and weight: 1/8 cubic to 1 cubic foot and 20 to 150 pounds, except small stones and spalls used to chink interstices shall weigh not less than 10 pounds and at least 50 percent of pieces shall weigh not less than 100 pounds.

C. Material shapes:
   1. Capable of forming stable protection structure of required depth.
   2. Rounded boulders or cobbles on 2:1 slopes and less.
   3. Angular.
   4. Flat or needle shapes with thickness more than 1/3 length.

2.02 GROUTED RIPRAP

A. Material: Rock, broken concrete from site preparation, or wasted concrete from job pours, 1/8 to 1 cubic foot 20 to 150 pounds.

B. Cement: In accordance with ASTM C 150, Type II.

C. Aggregate:
   1. Fine: Sand.
   2. Coarse: Gravel passing 3/8-inch square mesh screen.

D. Water: Clean.

E. Grout mix:
   1. Hand mix when acceptable to the Engineer or machine mix. 1 part cement, 2 parts fine aggregate, and 1 part coarse aggregate by volume, with water as required and acceptable to the Engineer to permit gravity flow of grout into interstices with limited spading and brooming.
   2. When hand mixing, thoroughly mix cement and aggregate in clean, tight mortar box until mixture is of uniform color, then add water in such quantity as to provide a grout of specified consistency.
   3. When machine mixing, mix in accepted machine for not less than 1-1/2 minutes.

PART 3 EXECUTION

3.01 PREPARATION

A. Shape and trim bed for riprap as required to provide even surface which at no point is higher than design surface.

B. Grade slopes on which sacked concrete riprap or gabions are to be placed to tolerance of 0.00 to minus 0.20 foot.

C. Excavate footing trench along toe and cutoff trench at top of slope, as indicated on the Drawings.

3.02 PLACING PLAIN RIPRAP

A. When required riprap is less than 20 inches in depth, place material by hand.

B. When riprap is 20 inches or more in depth, place material by dumping and spreading in layers by bulldozers or other suitable equipment.

C. Place material to provide minimum of voids.

D. Place larger pieces in toe of trench, foundation course, and on outer surface of riprap.

E. Place pieces with their longitudinal axis normal to face of embankment and so arranged that each piece above the foundation course has minimum 3-point bearing on underlying stones.
   1. Bearing on smaller pieces used to fill voids will not be acceptable.

F. Fill interstices between pieces with small pieces and spalls.

3.03 PLACING GROUTED RIPRAP

A. Place material in manner to provide minimum of voids.

B. Place larger pieces in toe trench, foundation course, and on outer surface of riprap.

C. Place pieces with their longitudinal axis normal to face of embankment and so arranged that each piece above foundation course has at least a 3-point bearing on underlying material.
   1. Fill interstices between pieces with small pieces and spalls. Bearing on smaller pieces used to fill voids will not be acceptable.

D. Grout with grout mix specified for grouted riprap.

3.04 TOLERANCES

A. Finished surfaces of riprap for plain or grouted riprap: Within 3 inches per foot of depth.

B. Finished surface of for sacked concrete riprap: Within 3 inches.

C. Finished surfaces of gabions: Within 3 inches.

END OF SECTION

SECTION 02581

PRECAST ELECTRICAL HANDHOLES AND ELECTRICAL MANHOLES

PART 1 GENERAL

1.01 SUMMARY

A. Design, fabricate, and install precast electrical handholes and precast electrical manholes of the size and type indicated on the Drawings and specified.
   1. Construction of cast-in-place concrete electrical structures, including handholes and manholes, are specified in other Sections.

B. Section includes:
   1. Precast portland cement concrete handholes and accessories.

C. Related sections:
   1. The Contract Documents are complimentary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's work.
   3. The following sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 02300 - Earthwork.
      e. Section 03150 - Concrete Accessories.
      f. Section 03300 - Cast-in-Place Concrete.
      g. Section 05500 - Metal Fabrications.
      h. Section 06611 - Fiberglass Reinforced Plastic Fabrications.
      i. Section 07110 - Dampproofing.
      j. Section 07900 - Joint Sealants.
      k. Section 09960 - Coatings.
      l. Section 16050 - Common Work Results for Electrical.
      m. Section 16070 - Hangers and Supports.
      n. Section 16133 - Duct Banks.

D. Alternates:
   1. Contractor may propose to construct cast-in-place structures in lieu of the precast structures specified.
      a. Obtain Engineer's acceptance of this alternative before submitting, providing, or installing.
      b. Submit full information on design and detailing of proposed alternatives including design details and drawings of the same types required by this Section for precast structures.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. C 857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   3. C 858 - Standard Specification for Underground Precast Concrete Utility Structures.
   4. C 891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.
   5. C 1028 - Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.
   6. C 1037 - Standard Practice for Inspection of Underground Precast Concrete Utility Structures.

D. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Safety Code (NEC).

E. National Precast Concrete Association (NPCA).

F. Society of Cable Telecommunications Engineers (SCTE):
   1. 77 - Specification for Underground Enclosure Integrity.

G. Underwriters Laboratories (UL)

1.03 DEFINITIONS

A. Handhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to reach into, but not enter, the enclosure to install, operate, or maintain equipment or wiring or both. (Reference: NEC, Article 100.)
   1. As used in this Section, “handhole” will refer to a precast electrical handhole.

B. Manhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to enter the enclosure to install, operate, or maintain equipment or wiring or both.
   1. As used in this Section, “manhole” will refer to a precast electrical manhole.

C. Portland cement concrete: A composite material consisting of a portland cement binder, water, admixtures, and a combination of fine and coarse mineral aggregates.
   1. Abbreviated “PCC” as in “PCC HANDHOLE” or “PCC MANHOLE.”

D. Precast concrete: A concrete fabrication designed by a qualified engineer and subsequently fabricated at a qualified fabrication site, which is usually located some distance from the site where the fabrication will be installed.

1.04 SYSTEM DESCRIPTION

A. General requirements for handholes and manholes:
   1. As specified in Section 16050 for general requirements for electrical work.
   2. Provide structures of the sizes and shapes indicated on the Drawings, with layouts, dimensions, and details as indicated on the Drawings and as specified.
   3. Conform to the requirements of:
      a. NEC.
      b. Project regulatory requirements as specified in Section 01410.

B. Polymer concrete handholes:
   1. Load resistance of boxes and covers.
      a. Conform to all provisions of SCTE 77 for Tier 5, 8, 15 or 22 applications as specified in this Section.
         1) Where multiple “Tiers” are specified, handholes shall adequately support compatible covers while providing the highest Tier rating specified.
         2) Load rating of cover for an assembly shall not exceed the load capability of the box below.
         3) Coefficient of friction between cover and box: Not less than 0.50 when measured in accordance with ASTM C 1028.
   2. Testing and certification.
      a. Each handhole to be installed shall have a report certifying that the design and construction of the unit has successfully passed all tests for materials and product performance required by SCTE 77.
         1) Testing and report shall be by a qualified testing agency, independent of the manufacturer. Test report shall bear the seal of a licensed professional engineer.
         2) Provide evidence of UL listing as required under by NEC for products to be provided.

C. Portland cement concrete handholes and manholes:
      a. Load resistance of boxes and covers.
   2. Design requirements: Loads on structures:
      a. In accordance with ASTM C 857, except as modified in this Section.
      b. Loads at the ground surface:
         1) See “Electrical Handhole and Manhole Schedule” indicated on the Drawings for minimum surface loading requirements at each structure. Loads are designated as “sidewalk,” or “roadway.”
         2) The vehicle and pedestrian loadings in the following paragraphs need not be additive; however structures designated for “roadway” loading shall also support “sidewalk” loads.
         3) “Sidewalk”: Load from regular pedestrian traffic with considerations for occasional non-deliberate vehicular traffic:
            a) Designation A-0.3 in ASTM C 857 Table 1; (300 psf uniform load).
         4) ”Roadway”: Load from heavy, frequently repeated vehicle traffic:
            a) Designation A-16 in ASTM C 857 Table 1 (AASHTO HS20-44).

c. Lateral earth pressure loads:
    1) Determine in accordance with the following requirements. Include effects of seismic accelerations on earth pressures.
        a) Equivalent lateral pressure: 65 pounds per square foot per foot of depth (triangular distribution) plus backfill-induced live load surcharge of 80 pounds per square foot (rectangular distribution).
        b) Surface surcharge load: In accordance with ASTM C 857 A-16 wheel load if such surcharge exceeds backfill loads described in the preceding paragraph.
        c) Seismic acceleration effects:
            (1) As specified in Section 01612.

d. Soil bearing pressure at base:
    1) Maximum 2,500 pounds per square foot total pressure on prepared subgrade soils.

e. Lifting and handling loads:
    1) Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.

f. Load combinations:
    1) Design structures to sustain the specified loads individually or in combination.

3. Design requirements: Structural analysis, design and detailing:
    a. General:
        1) Analyze and design structures including the effects of 2-way action (“plate action”) and of load transfer around current and future openings.
        2) Where structures include panels designed for future removal (“knockout panels”), design structures for loads and stresses with any combination of any or all such panels in place or removed.
    b. Precast portland cement concrete handholes and manholes:
        1) Design structures in accordance with the requirements of ACI 318 and this Section.
        2) Provide reinforcement at all areas subject to tensile stress when loaded with the specified loads and combinations thereof.
        3) Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in all concrete sections.
        4) Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of all members in accordance with the following:
            a) Handholes: 2.0 inches.
            b) Manholes: 2 inches.
        5) Reinforcement details:
            a) Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
            b) Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
            c) Structures with wall or slab thicknesses exceeding these limits shall have reinforcement at each face of the member.

6) Joints:
a) Provide structures with watertight joints between sections, and detailed to minimize water infiltration at duct bank and conduit penetrations.
b) Provide structures with non-skid, shiplap, or tongue and groove joints between sections.

4. Design requirements: Materials:
a. Portland cement concrete handholes and manholes:
1) In accordance with ASTM C 858.

1.05 SUBMITTALS

A. Product data: Manufacturer's catalog data, details, and warranties for the following items.
1. Portland cement concrete handholes and manholes:
a. Joint details and joint sealing materials.
b. Data for hatches or covers and rings.
c. Preformed channels and accessories for cable racking.
d. Drain and sump details, including removable covers.
e. Pulling iron details.

B. Shop drawings:
1. Portland cement concrete handholes and manholes:
a. Shop drawings for each structure shall bear the seal and signature of a structural engineer licensed in the state where the structures will be installed.
b. Dimensioned and "to scale" plans, sections, and details for each structure including:
1) Layout plan for that structure.
2) Sizes, locations, and vertical positions of duct bank windows and knockout panels.
3) Locations and details for access openings, pulling irons, embedded cable supports and racks, and sumps.
4) Details of structural reinforcement showing bar size and spacing; true position of reinforcement in structural members with clear concrete cover at both inside and outside faces; location, bar size, and spacing of added reinforcement around openings; and other details relevant to design and fabrication of the structure.
5) Details of joints between adjacent precast sections, including provisions for overlap and for placement of sealants.

C. Design data:
1. Portland cement concrete handholes and manholes:
a. Structural calculations:
1) Submit complete structural calculations for each structure.
2) Provide calculations bearing the seal and signature of a professional engineer licensed in the state where the structures will be installed.

b. Manufacturer's statement of materials used for fabrication and construction, in accordance with ASTM C 858, for record. Include the following:
    1) Concrete mix design: For each concrete mix design to be used for the structures, include data describing:
        a) Source and type of cement.
        b) Sources, grading and specific gravities of aggregates.
        c) Aggregate reactivity data.
        d) Concrete mix proportions and design strength.
        e) Type, name, and dosage of all admixtures included in the concrete mix.
    2) Reinforcing steel: Mill certificates.

D. Test reports:
1. Polymer concrete handholes:
    a. Independent laboratory test reports bearing the seal of a licensed professional engineer and demonstrating compliance with the requirements of SCTE 77 for the loading conditions specified.
2. Portland cement concrete handholes and manholes:
    a. Fabricator's tests for compressive strength of concrete used in structures, made in accordance with recommendations of ASTM C 858.

E. Certificates:
1. Polymer concrete handholes:
    a. Manufacturer's certification that polymer concrete handholes in accordance with the requirements of SCTE 77.
2. Portland cement concrete handholes and manholes:
    a. Manufacturer's current plant certification under NPCA for the structures to be supplied.
        1) Certification shall be current and in-effect at the time structures are manufactured.
    b. Manufacturer's certification that handholes and manholes in accordance with the requirements of ASTM C 858.

F. Manufacturer's instructions:
1. Instructions for handling and setting structures in place.
2. Portland cement concrete handholes and manholes:
    a. Instructions for operation and maintenance of hatches.

G. Manufacturer's field reports:
1. Portland cement concrete handholes and manholes:
    a. Manufacturer's inspection reports in accordance with ASTM C 1037.

H. Closeout documents:
1. Project record documents:
    a. Portland cement concrete handholes and manholes:
        1) Final, revised plans and details of as-constructed precast handholes and manholes if requested for record by the Engineer.
2. Warranties.
    a. Manufacturer's standard warranty for:
        1) Polymer concrete handholes.
        2) Portland concrete handholes, manholes, and accessories.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Designer:
      a. Portland cement concrete handholes and manholes:
         1) Structural engineer qualified in the design of concrete structures and holding a current license in the state where the structures will be installed.
   2. Manufacturer:
      a. Polymer concrete handholes:
         1) Demonstrating at least 5 years' experience in the design and production of products of the type required for this Work.
         2) Holding product testing records demonstrating load resistance of products to be installed.
      b. Portland cement concrete handholes and manholes:
         1) Holding current NPCA plant certification for the products produced.
         2) Demonstrating at least 5 years' experience in the design, production, and installation of products of the type required for this Work.
         3) Capable of providing structural designs prepared by a professional engineer licensed in the state where the structures will be installed.
         4) Providing inspection during fabrication and handling in accordance with the requirements of ASTM C 1037.
   3. Installer:
      a. Capable of providing equipment of adequate capacity and mobility to handle and set units with proper bearing on the subgrade and without damage to the unit.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing, shipping, handling and unloading:
   1. Package and brace structures to avoid damage during shipping and handling.
   2. Furnish crane or forklift for unloading and setting of portland cement concrete handholes and manholes.

B. Acceptance at site:
   1. Structures delivered to the site with cracks, damage, and damaged or missing accessories shall be removed from the site and replaced at no additional cost to the Owner.

C. Storage and protection:
   1. Store handholes, manholes, and their appurtenances in areas protected from damage due to weather and site operations.
   2. Portland cement handholes and manholes.
      a. Protect during backfill and other site construction.

1.08 PROJECT CONDITIONS

A. Environmental requirements: As specified in Section 01610.

1.09 SEQUENCING

A. Coordinate installation of precast electrical handholes and manholes with duct banks specified in Section 16133.

1.10 WARRANTY

A. Provide manufacturer's standard warranty for precast handhole and manhole structures and accessories.

1.11 SYSTEM STARTUP

A. As specified in Section 16050.

1.12 MAINTENANCE

A. Extra Materials (not used)

PART 2 PRODUCTS

2.01 MATERIALS

A. Cast-in-place concrete for fill at base sections of portland cement concrete manholes with deep sumps or ballast to resist buoyancy shall be "Class A" concrete as specified in Section 03300.

2.02 SOURCE QUALITY CONTROL

A. Portland cement concrete handholes and manholes.
   1. Manufacturer's QC Department shall inspect and approve units prior to loading chemicals for delivery.

2.03 MANUFACTURED UNITS - POLYMER CONCRETE HANDHOLES

A. General:
   1. Enclosures, boxes, and cover shall conform to all test provisions of SCTE 77.

B. Manufacturers: One of the following, or equal.
   1. Quality Division of Hubble, Incorporated.
   2. Carson Industries, LLC.

C. Materials:
   1. Polymer concrete with optional fiberglass reinforcement.
      a. Handholes constructed of plastic or fiberglass will not be permitted

D. Components:
   1. Cover:
      a. Provide casketed cover with lifting slot and stainless steel hex head bolts for attachment to box.
      b. Fasten cover to box using stainless steel hex head bolts.
      c. Skid-resistant surface. Coefficient of friction for walking surface on top of cover shall be at least 0.50 when measured in accordance with ASTM C 1028.
      d. Custom logo not required.

2. Box:
    a. Open-bottom base unless otherwise indicated on the Drawings.
        1) Stackable sections with interlocking joints to maintain horizontal and vertical alignment.
    b. Provide knockouts, terminators, pulling eyes, and inserts as required for a complete installation.
3. Fabrication:
    a. All components in assembly (boxes and cover) shall be manufactured using matched surface tooling for consistency of production.

E. Load rating:
1. Provide "TIER" rating based on Schedule of Electrical Handholes and Electrical Manholes indicated on the Drawings, and the following loading requirements:

Surface Loading Rating	Requirements
"Sidewalk"	"TIER 15" - "Medium Duty" For driveway, parking, and ramp areas where vehicle wheel loads will not exceed 2000 pounds on a single wheel.
"Roadway"	Not allowed. - "Heavy Duty" For highway traffic or AASHTO wheel loads of at least 16,000 pounds.

2. Provide covers with "TIER" rating embossed or cast into the top surface.
3. Design load rating of cover for an assembly may not exceed the design load rating of the box below.

F. Accessories:
1. Provide two non-corroding steel lifting hooks for removing covers.

2.04 MANUFACTURED UNITS - PORTLAND CEMENT CONCRETE HANDHOLES AND MANHOLES.

A. General:
1. Provide portland cement concrete handholes and manholes configured and designed as indicated on the Drawings and specified.
2. In accordance with ASTM C 858 unless otherwise noted.
    a. Concrete. Provide units with minimum specified compressive strength (face) of 4,000 pounds per square inch and using Type II cement.

B. Manufacturers: One of the following, or equal:
1. Oldcastle Precast.
2. Jensen Precast.
3. Hanson Precast.

C. Components:
1. Floor:
    a. Construct floors as a monolith.
    b. Where sump or low-point drain is included, slope floor to that point.

2. Roof, walls, and base:
    a. Designed and rated to support vehicle and pedestrian loads at the spans indicated.
    b. See the Electrical Handhole and Manhole Schedule indicated on the Drawings for required load rating by structure location.
3. Access covers:
    a. Handholes: Aluminum plate hinged floor access door (hatch).
        1) Load rating:
            a) “Heavy Duty” for covers at locations designated for “Roadway” loads.
            b) “Medium Duty” or stronger for covers at locations designated for “Sidewalk” loads.
        2) Minimum access door size not less than 36 inches square, unless otherwise indicated on the Drawings.
        3) Provide bearing surface with pre-installed continuous elastomeric gasket to minimize water infiltration at lid.
        4) Provide skid-resistant lid with cast-in or machined-in grid pattern and the word “ELECTRICAL” in block letters at least 1.5 inches high.
    b. Manholes: Cast iron frame and cover.
        1) Manhole rings and covers:
            a) Gray cast iron in accordance with ASTM A 48, Class 30B with ring and cover machined to fit with flat bearing surfaces.
            b) In accordance with Owner’s standard design.
            c) Cover with word “ELECTRICAL” cast into the top exposed face for electrical manholes.
            d) Manhole riser access:
                (1) Heavy-duty top flange frame with solid cover for embedment in top slab of a structure.
                (2) 36-inch diameter nominal opening.
                (3) Security bolting: Manufacturer’s standard security bolting.
                (4) Manufacturer: The following or equal.
                    (a) Neenah Foundry Company, R6095.

D. Accessories:
1. Provide accessories as indicated on the Drawings and specified.
2. Materials at duct bank penetrations:
    a. Joint filler as specified in Section 03150.
    b. Backer rod and sealant as specified in Section 07900.
3. Pulling irons:
    a. Provide non-corroding cable pulling irons located for use with each current duct bank location and additional irons for use with duct banks that may be installed though future knockout panels.
    b. Pulling irons may not be located on the floor.
    c. Where pulling irons are installed on the wall, any pockets surrounding the irons shall have bottom surfaces sloped to drain.
    d. Secure pulling eyes to structure reinforcement.
4. Cable racks and racking hardware:
    a. Materials: Hot-dip galvanized steel.
    b. Embedded slots: Maximum depth of 1.5 inches.

5. Ladders and manhole rungs:
    a. Ladders:
        1) In accordance with OSHA Subpart D “Requirements for walking and working surfaces.”
        2) Aluminum as specified in Section 05500.
    b. Manhole rungs:
        1) Fiberglass manhole rungs in accordance with OSHA Subpart D “Requirements for walking and working surfaces.”
6. Sumps and drains:
    a. Fiberglass or HDPE fabrications including removable lids to prevent tripping hazards.
7. Grounding conductor:
    a. Furnish a 4/0 bare copper grounding electrode conductor cast into the floor slab of each handhole and manhole.
    b. Provide minimum 8-foot length of exposed conductor for grounding connection to duct bank grounding conductor(s).
8. Exterior dampproofing:
    a. As specified in Section 07110.
    b. Field applied to all wall and roof surfaces exposed to soil.

E. Fabrication:
1. Embeds:
    a. Install embedded items with provisions for drainage to remove dripping or standing water, and to minimize corrosion.
        1) Pulling irons may not be placed on the floor or in pockets that will collect water.
        2) Detail bottom of cable rack channels to provide a downward sloping “sill” at the bottom of each vertical channel, so that the channel slot drains toward the floor.
    b. Concrete cover:
        1) Provide minimum 0.75-inch clear concrete cover between embeds and surrounding reinforcement.
        2) Provide minimum 1.25-inch clear concrete cover between embed and exterior face of wall.

F. Tests, inspections:
1. Test and inspect structures in accordance with ASTM C 858 and C 1037.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install precast electrical handholes and manholes as indicated on the Drawings and specified.

B. Install additional handholes and manholes required so installation procedures will conform to cable manufacturer’s pulling tension requirements.
1. Include proposed locations and details of such additional handholes and manholes with the submittals under Part 1.

3.02 EXAMINATION

A. Notify City Engineer when manhole is ready for inspection, prior to backfilling.

3.03 PREPARATION

A. Design:
   1. Prepare detailed and scalable layouts for each manhole structure showing locations of conduit or duct bank penetrations, clearances, locations, and sizes of access openings, and major accessories.

B. Protection:
   1. Where handhole and manhole structures are installed adjacent to existing site structures or utilities, provide excavation support or other protection as required to maintain those facilities in service and to prevent damage to both existing and new facilities.

C. Site preparation:
   1. Excavate and prepare exposed subgrade as indicated on the Drawings and as specified.
   2. Install and compact 8-inch thick foundation layer of ABC.
   3. Level foundation materials so that structures will be set plumb and duct banks will be at proper grade and alignment.
      a. Install with uniform bearing on foundation materials.
      b. Wedging or blocking of base sections for leveling over the foundation materials will not be permitted.

3.04 INSTALLATION

A. General:
   1. Protect handholes and manholes from displacement, flooding, or flotation.

B. Polymer concrete handholes:
   1. Install structures in accordance with the manufacturer's recommendations.
   2. Clean joints between adjacent sections for tight fit.
   3. Set covers at elevations indicated on the Drawings.
      a. Securely attach cover to below-grade box.
   4. Backfill polymer concrete handholes as indicated on the Drawings and as specified.

C. Portland cement concrete handholes and manholes:
   1. Install structures in accordance with ASTM C 891 and the provisions of this Section.
      a. In the event of conflicts, the more restrictive provisions shall apply.
   2. Clean and prime joints between adjacent precast sections.
      a. Install sealing compound between sections and provide watertight joints.
   3. Set covers and hatches at elevations indicated on the Drawings.
      a. Securely attach frames to top of precast structures and grade adjustment rings.
   4. Penetrations:
      a. Holes for duct banks and other penetrations may not be cut into precast handholes and manholes unless they are located at designated locations

shown on the shop drawings or at knockout panels cast into the structure during manufacturing.

b. Carefully remove concrete from knockout panel areas with saws.
   1) Ensure that break-back does not extend beyond the designated limits of the knockout panel.

c. Coat any reinforcement cut or exposed during removal of knockout panel sections with minimum 2 coats of High Solids Epoxy as specified in Section 09960.
   1) Apply epoxy coating applied over and at least 1-inch past the perimeter of the reinforcement.

5. Install duct banks and conduit penetrations in accordance with the penetration details indicated on the Drawings.
   a. Place all joint fillers, caulks, and sealants before coating exterior concrete surface with bituminous dampproofing.
6. Fill holes that were provided for handling or other temporary purposes with non-shrink cement grout using procedures as specified in Section 03300 unless otherwise detailed by the manufacturer.
7. After structures are set and before backfilling, coat exterior below-grade surfaces (around the sidewalls, over the top slab, and around any vertical risers to grade) with 2 heavy coats of bituminous dampproofing as specified in Section 07110.
   a. Apply dampproofing in accordance with the coating manufacturer's instructions and at a rate of 40 to 60 square feet per gallon per coat.
   b. Mask over and at least 1 inch back from joint caulks or sealants, and prevent dampproofing from coming in contact with those materials.
8. Backfill handholes and manholes as specified in Section 02300.

D. Site tolerances:
   1. Set electrical handholes and manholes plumb and true at locations indicated on the Drawings.
   2. Tolerances on placing:
      a. Horizontal location: Plus or minus 1 inch.
      b. Vertical elevation: Plus or minus 1/2 inch.
      c. Plumb: Plus or minus 1/8 inch over 10 feet.

3.05 REPAIR / RESTORATION

A. Repair cracks or blemishes in concrete as described in Section 03300. Submit proposed repairs for acceptance before commencing work.

3.06 FIELD QUALITY CONTROL

A. Special inspections.
   1. Contact Engineer when installation complete and ready for final inspection.

3.07 ADJUSTING

A. After final grading is complete, adjust access covers to grade.

3.08 CLEANING

A. Before installation of cables in any duct banks and handholes or manholes, remove all concrete spoil, forms, debris, silt, dust, and other foreign material.

B. Pressure wash interior of structures if required to provide clean interior surfaces.
   1. Block drains and provide pumps to remove washwater from structures.
   2. Do not permit washwater to drain into subgrade soils.

3.09 PROTECTION

A. Protect handholes and manholes from construction equipment.

3.10 SCHEDULES

A. See Drawings for Electrical Handhole and Electrical Manhole Schedule.

END OF SECTION

SECTION 02620

FILTER FABRIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Nonwoven filter fabric.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   2. D 4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   3. D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   4. D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   5. D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   6. D 5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   7. D 6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

A. Filter fabric: Nonwoven geotextile fabric manufactured from polypropylene fibers.

1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
   1. Furnish filter fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

A. Take field measurements to determine the lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Propex, Geotex 401.
   2. Ten Cate Geosynthetics, Mirafi 140N.

2.02 MATERIAL REQUIREMENTS

A. Physical properties: Meet the following minimum requirements:

Property (1)	Test Method	Unit	Requirements (1)
Minimum Weight	ASTM D 5261	oz	4.0
Grab Tensile Strength	ASTM D 4632	lbs	100
Grab Elongation	ASTM D 4632	%	50
Trapezoid Tear Strength	ASTM D 4533	lbs	50
CBR Puncture Resistance	ASTM D 6241	lbs	300
UV Resistance (strength retained at 500 hrs)	ASTM D 4355	%	70
Apparent Opening Size (AOS)	ASTM D 4751	US sieve	70
Permittivity	ASTM D 4491	sec^{-1}	1.7
Flow Rate	ASTM D 4491	gpm/ft^2	130
(1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of filter fabric.

3.02 PREPARATION

A. Surface preparation:
   1. During grading operations, take care not to disturb the subgrade.
   2. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

A. Follow manufacturer's installation instructions and as complimented herein.

B. Place the filter fabric smoothly without folds or wrinkles.

C. Use special care when placing the filter in contact with the soil so that no void spaces occur between the filter and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than manufacturer's instructions.

E. Do not drag filter fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers if necessary. Do not allow equipment directly on filter fabric.

3.04 FIELD QUALITY CONTROL

A. Inspection:
   1. Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric.
   2. Repair all holes and rips by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 02722

AGGREGATE BASE COURSES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Aggregate base course.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02300- Earthwork.

1.02 REFERENCES

A. Sponsored and Distributed by the Maricopa Association of Governments - Arizona, 1998 Edition, with updates:
   1. Uniform Standard Specifications for Public Works Construction.

B. ASTM International (ASTM):
   1. C 117 - Standard Test Method for Materials Finer than 75 µM (No. 200) Sieve in Mineral Aggregate by Washing.
   2. C 131 - Standard Test Method for Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.03 SUBMITTALS

A. Product data:
   1. Source.
   2. Gradation.
   3. Testing data.

B. Quality control:
   1. Test reports: As required by Sections Uniform Standard Specification for Public Works Construction.
   2. Certificates of Compliance: As required by Sections of Uniform Standard Specification for Public Works Construction.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aggregate base course:
   1. Consist of hard, durable particles or fragments of stone or gravel, screened or crushed to required size and grading and free from vegetable matter, lumps or balls of clay, alkali, adobe, or other deleterious matter.
   2. Materials derived from processing demolished or removed asphalt concrete are not acceptable.
   3. Materials derived from processing demolished or removed asphalt concrete can be blended with approved base course material and used only as base course under asphaltic concrete paving. It cannot be used as structural backfill under or around any buried facilities.
   4. When sampled and tested in accordance with specified test methods, material shall comply with following requirements:
      a. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C 131.
      b. Plasticity index: Not be more than 5 when tested in accordance with ASTM D 4318.
      c. Liquid limit: Not be more than 25 percent when tested in accordance with ASTM D 4318.
   5. Aggregate base course for structures:
      a. Consist of crushed or fragmented particles.
   6. Conform to size and grade within limits as follows when tested in accordance with ASTM C 117 and ASTM C 136:

Sieve Sizes (Square Openings)	Percent by Weight Passing Sieve
1-1/8 inch	100
Number 4	38-65
Number 8	25-60
Number 30	10-40
Number 200	3-12

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine conditions upon which the work specified in this Section depends for defects that may influence installation and performance.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Subgrade preparation: Prepare as specified in Section 02300.

3.03 INSTALLATION

A. Furnish, spread, and compact material to the lines, grades, and dimensions indicated on the Drawings:
   1. Spread in accordance with sections of Standard Specifications. Compact in accordance with sections of Standard Specifications.

3.04 FIELD QUALITY CONTROL

A. Tests: Perform field tests as required by sections of Standard Specifications.

END OF SECTION

SECTION 02738

DECOMPOSED GRANITE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Decomposed granite.

1.02 SUBMITTALS

A. Product data: Submit for chemical agents. Include material safety data sheets, Environmental Protection Agency registration number, and manufacturer's instructions for handling, storing, mixing, and application.

B. Shop drawings: Submit gradation analysis from lot.

C. Samples: Provide sample showing color and texture.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at site: Provide load tickets indicating weight and conformance with submittals.

B. Storage and protection:
   1. Protect delivered material from contamination by, or mixing with, other materials.

C. Handling:
   1. Handle, mix, and apply chemicals in accordance with applicable regulations and manufacturer's instructions. When required, use licensed applicator.
   2. Store chemicals in accordance with hazardous material regulations.

1.04 PROJECT CONDITIONS

A. Existing conditions:
   1. Verify before beginning work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Decomposed granite:
   1. Provide granite that is free from lumps or balls of clay and that does not contain calcareous coatings, caliche, organic matter, or deleterious substances, and is "Desert Gold" in color.
   2. Color and source of decomposed granite: Subject to acceptance by the Engineer.

3. Provide materials that present uniform appearance and are from single production source.
4. Grading requirements: As follows:

Sieve Size	Percent Passing
3/4 inch	95 - 100
1/2 inch	85 - 95
Number 4	30 - 40
Number 40	0 - 10

5. Reject material containing clumps, which will not disintegrate with shovel blow.

B. Chemical control agent: Spectracide (United Industries Corporation), Roundup (Monsanto Company), or equal.

C. Pre-emergence control agent: Pre-emergent herbicide. Fatam pre-emergent weed control (Dexol) or equal.

D. Water: Potable and exhibiting no deleterious effects upon decomposed granite.

PART 3 EXECUTION

3.01 PREPARATION

A. Surface preparation:
1. Prior to placing decomposed granite perform following operations to areas designated to receive granite:
   a. Apply chemical control agent in manner to ensure areas are totally free of weeds.
   b. Grade to true and even condition.
   c. Apply pre-emergence control agent in accordance with manufacturer's instructions.

3.02 INSTALLATION

A. Installation of decomposed granite:
1. Apply evenly distributed granite at designated areas to depth of 6 inches.
2. After placing and grading decomposed granite, lightly water granite to remove fine material from surface.
3. Then apply pre-emergent control agent according to manufacturer's recommendations.
4. Roll and compact to a smooth, even surface with a steel wheeled roller.

B. Tolerances:
1. Thickness shall not be less than specified.
2. Surface to be plus or minus 1 inch along a 10-foot straight edge.

3.03 PROTECTION

A. Protect from damage by elements, erosion, vehicles, and mixing with contaminating substances.

END OF SECTION

SECTION 02742

ASPHALTIC CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Asphalt concrete pavement on prepared subgrade or aggregate base course, and on existing pavement, to lines, grades, compacted thicknesses, and cross sections indicated on the Drawings.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Transportation Materials and Methods of Sampling and Testing:
      a. MP1: Specification for Performance Graded Asphalt Binder.

B. ASTM International (ASTM):
   1. C 117 - Standard Test Method for Material Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. D 977 - Standard Specification for Emulsified Asphalt.
   5. D 2041 Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
   6. D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

C. Maricopa Association of Governments (MAG) Uniform Standard Specifications for Public Works Construction
   1. Section 710 – Asphalt Concrete Pavement

1.03 DEFINITIONS

A. Bituminous prime coat: Consist of application of hot bituminous material on previously prepared base course.

1.04 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Compact the asphalt concrete to at least 95 percent of the density of the theoretical maximum density in accordance with ASTM D2041.

1.05 SUBMITTALS

A. Proposed mix design and gradation of materials.

B. Quality control submittals:
   1. Certificate of Compliance.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Asphalt concrete delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of all foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Asphalt concrete:
      a. Place asphalt concrete only when surface is dry, when atmospheric temperature in the shade is 40 degrees Fahrenheit and rising, or above 50 degrees Fahrenheit if falling.
      b. Do not place asphalt concrete when weather is foggy or rainy nor when base on which material is to be placed is in wet or frozen condition.
   2. Prime coat:
      a. Do not apply prime coat when atmospheric temperature is below 60 degrees Fahrenheit.
      b. Apply prime coat only when base course is dry or contains moisture not in excess of that which will permit uniform distribution and desired penetration.

1.08 SEQUENCING AND SCHEDULING

A. Prime coat:
   1. Prior to requesting Engineer's acceptance for application, inspect area to be coated to determine its fitness to receive bituminous priming material.
   2. Do not begin application before area to be coated has been accepted for application by the Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

A. Prime coat: Use bituminous material for prime coat conforming to requirements for SC-70 and apply at temperature of 105 to 175 degrees Fahrenheit at rate of 0.3 to 0.6 gallons per square yard by use of bituminous distributor.

B. Sand: Acceptable to the Engineer.

C. Tack coat: Grade SS-1h anionic emulsion in accordance with ASTM D 977.

D. Asphalt concrete materials:
   1. Asphalt concrete conforming to the current requirements in Section 710 of the Uniform Standard Specifications for Public Works Construction published by

the Maricopa Association of Governments (MAG), 1/2-inch or 3/4-inch mix design.

1. In accordance with MAG Specificaiton 710, the asphalt binder shall be performance grade asphalt confomrating to requirements of MAG Specification 711 for PG 70-10.
3. Mineral aggregate:
   a. Consist of coarse aggregate of crushed stone or gravel composed of hard, durable particles, sand, and filler as follows:
      1) Coarse aggregate: Portion of material retained on Number 8 sieve.
      2) Fine aggregate: That portion passing Number 8 sieve.
   b. Provide composite material that is uniformly graded from coarse to fine and that complies with requirements of one of following gradings when tested in accordance with ASTM C 136.
   c. Asphalt concrete: As indicated on the Drawings, 2 course plant mix for asphalt concrete having an overall thickness of 2 1/2 inches or more if not indicated. If less than 2 1/2 inches asphalt concrete, use single course plant mix.

Plant Mix, Two Course				**Plant Mix, Single Course**	
Seal, 3/4 inch Thick Minimum		**Base, 1-3/4 inch Thick Minimum**		**1-1/2 inch Thick Minimum**	
Sieve Size	**Percent Passing**	**Sieve Size**	**Percent Passing**	**Sieve Size**	**Percent Passing**
1/2"	100	1-1/4"	100	3/4"	100
3/8"	95 - 100	1"	87 - 100	1/2"	75 - 95
No. 4	50 - 70	3/4"	75 - 90	3/8"	65 - 85
No. 8	35 - 55	3/8"	55 - 72	No. 4	50 - 65
No. 30	15 - 30	No. 4	40 - 60	No. 8	35 - 50
No. 100	5 - 15	No. 8	30 - 50	No. 30	15 - 30
No. 200	3 - 8	No. 30	15 - 30	No. 100	5 - 15
		No. 100	5 - 15	No. 200	3 - 8
		No. 200	3 - 8		

4. Coarse aggregate:
   a. Consist of at least 70 percent by weight of each size aggregate and consist of particles, which have at least 1 rough, angular surface produced by crushing:
      1) Have percentage of wear of not more than 50 at 500 revolutions, in accordance with ASTM C 131.
   b. Aggregate plasticity index: Not more than 2 in accordance with ASTM D 4318.
   c. Sand may be added to crusher or pit run product to supply any deficiency in 8-mesh size, and filler may be added to supply any deficiency in 200-mesh material. If aggregate contains an excess of sand, wasting will be required.

d. Filler:
    1) Use finely powdered limestones, portland cement, or other artificially or naturally powdered mineral dust, acceptable to the Engineer.
    2) Weigh filler and add separately to each batch at time of proportioning.
    3) Use filler that is free from deleterious matter of any kind.
    4) Fineness that meet the following requirements:
        a) Passing 50 mesh sieve: 100 percent.
        b) Passing 200 mesh sieve: At least 75 percent.
    5) Determine amount of material passing the Number 200 sieve in accordance with ASTM C 117.
e. Provide composite aggregate that is free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter which would prevent thorough coating of asphalt cement.
f. Materials derived from processing demolished, or removed asphalt concrete, are not acceptable.

E. Fog sealing: Asphalt emulsion, Grade SS-1h.

2.02 EQUIPMENT

A. Bituminous distributor: Designed and equipped so as to distribute bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rate with pressure range of 25 to 75 pounds per square inch.

B. Liquid asphalt distributor:
1. Designed and operated to distribute asphaltic material in uniform spray without atomization.
2. Equipped with bitumeter having dial registering feet of travel per minute.
    a. Locate dial so that it is visible to truck driver so that he can maintain constant speed required for application at specified rate.
3. Equip pump with tachometer having dial registering gallons per minute passing through nozzles.
    a. Locate dial so that it is readily visible to operator.
4. Provide means for accurately indicating temperature of asphaltic material in distributor at all times.
    a. Locate thermometer well so that it is not in contact with, or close to, heating tube.
5. Have spray bar having normal width of application of not less than 12 feet and capable of providing for application of lesser width when necessary.
6. Provided with hose and spray nozzle attachment for applying asphaltic material to patches and areas inaccessible to spray bar.
7. Equipped with heating attachments and capable of circulating asphaltic material through spray bar during entire heating process.

C. Asphalt concrete mixing plants:
1. Equipment:
    a. Use screen and storage bins at plant of sufficient capacity to furnish the necessary amount of all aggregates, when operating at the maximum capacity of the plant, with no periods of undue waiting for material.
        1) Use bins consisting of at least 2 compartments, so proportioned as to insure adequate storage of appropriate fractions of the aggregate.

2) Provide each compartment with an overflow pipe of such size and at such location as to prevent any backing up of material into other compartments.

b. Dryer:
1) Designed to heat and dry the aggregate to Specification requirements and to agitate it continuously during the heating.
2) Capable of preparing aggregates at a rate equal to the full-rated capacity of the plant.

c. Dust collector:
1) So constructed as to waste or return uniformly to the hot elevator all or any part of the material collected.

d. Mixer:
1) Adequate capacity, with twin shafts.

e. Thermometers:
1) Furnished for determining the temperature of the mix.

f. Weighting and measuring equipment:
1) Weighing or volumetric measuring equipment of sufficient capacity.
2) Devices to permit easy readjustment of any working part needing readjustment, so that the equipment will function properly and accurately.
3) Attach scales for weighing to the bucket.
4) Test and seal all weighing equipment by a representative of the Inspector of Weights and Measures having jurisdiction, as often as the Engineer may deem necessary to insure accuracy.

g. Tanks for storage of bituminous material:
1) Capable of heating the material under effective and positive control at all times to temperatures within the range stipulated.

2. Asphalt concrete plant operation:
a. Mineral aggregate:
1) Dry and heat mineral and then screen into at least 2 fractions and conveyed into separate compartments ready for proportioning and mixing.
2) When combined with asphalt cement:

b. Aggregate:
1) Contain not more than 2 percent moisture by weight.
2) Be at a temperature within the range of that specified for the asphalt cement but not more than 25 degrees Fahrenheit above the temperature of the asphalt cement.

c. Combine dry aggregate in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified grading.
1) Introduce the asphalt cement into the mixer in the amount and at the temperature for the particular material being used.
2) Continue mixing for at least 30 seconds, and for such longer period as may be necessary to coat all the particles.

d. When a continuous mixer is used, determine the mixing time by weight method using the following formula:
1) Mixing time in seconds = Pugmill dead capacity in pounds.
2) Pugmill output in pounds per second.

D. Asphalt concrete placing equipment:
1. Use equipment for placing, spreading, shaping, and finishing asphalt concrete consisting of a self-contained power machine operating in such manner that no

supplemental spreading, shaping, or finishing is required to provide surface which complies with requirements for smoothness contained in this Section.
    a. In areas inaccessible to the machine, hand spreading may be permitted.
2. Furnish 1 self-propelled, pneumatic-tired roller, and one 8 ton (minimum), smooth-wheel tandem roller.
    a. When spreading is in excess of 100 tons per hour, furnish 1 additional roller of either type for each additional 100 tons, or fraction thereof, spread per hour.

2.03 MIXES

A. Asphalt cement:
    1. Do not mix at temperatures lower than 275 degrees Fahrenheit nor higher than 325 degrees Fahrenheit.
    2. Usual amount of asphalt cement, by weight, to be added to aggregate be 5.4 to 5.8 percent of weight of mixture.

B. Asphalt concrete:
    1. Before being delivered to the site, mix aggregate with asphalt cement at central mixing plant.
    2. Use mixing plants that are in good working order with no excessively worn parts and so equipped that:
        a. Temperatures of aggregates leaving dryer, of asphalt cement entering mixer, and of mix leaving mixer can be readily determined and positively controlled within Specification limits at all times.
        b. Weights of different sizes of aggregates and of asphalt cement as set by the Engineer can be consistently introduced into mixer.
        c. Asphalt cement can be uniformly distributed throughout mixture with aggregate completely coated.
        d. Mixing time can be positively controlled to minimum specified.
        e. Bin samples of aggregate can be readily obtained.
        f. Provide means of calibrating weighing devices.

PART 3 EXECUTION

3.01 PREPARATION

A. Protection
    1. Prime coated surfaces:
        a. Maintain surfaces until succeeding layer of pavement has been placed.
        b. During this interval, protect primed surfaces against damage and repair any broken spots.

B. Surface preparation:
    1. Prime coat:
        a. Where portions of base course prepared for immediate treatment are excessively dry, sprinkle such portions lightly with water immediately in advance of prime coat application.
        b. Immediately following preparation of base course, apply bituminous material by means of bituminous distributor at the temperature previously specified.

c. Apply priming material in manner that results in uniform distribution being obtained at all points of surface to be primed.
d. Following the application of prime material, allow the surface to dry for a period of not less than 48 hours without being disturbed, or for such additional period of time as may be necessary to obtain penetration into the base course and drying out or evaporation of the volatiles from prime material.
e. Spread sufficient sand on areas which show an excess of bituminous material to effectively blot up and cure the excess.

2. Base courses:
   a. Thoroughly clean base and apply prime coat before placing asphalt concrete.
   b. Thoroughly clean any existing base, surfacing, or pavement prior to placing plant-mixed surfacing.
   c. Where existing pavement is being widened or extended cut to straight vertical face and treat with asphalt paint binder prior to paving operations.
   d. When asphalt concrete is to be applied over existing pavement and local irregularities in existing surface would result in course of more than specified thickness, bring surface of existing pavement to uniform contour by patching with asphalt concrete thoroughly tamped or rolled until it conforms with surrounding surface, and then apply tack coat.

3.02 APPLICATION

A. At existing asphalt to be paved over: Apply tack coat at minimum rate of 0.10 gallons per square yard.

B. Placing and compacting asphalt concrete:
   1. Placing and compacting asphalt mixture: Progress in sections generally not more than 750 linear feet in length.
   2. Spreading of mixture:
      a. Spread, shape, and finish by specified equipment.
      b. Spread each successive strip adjacent to previously spread strip.
      c. Do not compact minimum 6-inch width of each strip adjacent to new strip until after new strip has been placed.
      d. Spread as nearly continuous as possible.
      e. Laying against vertical surfaces such as gutters: Roughen and clean face of vertical surfaces as required for proper bonding and then paint with light coating of asphalt cement or emulsified asphalt.
      f. At terminations of new surface courses: Feather asphalt mixture into existing surface over such distance as may be required to produce smooth riding transition.
      g. Base course and single course construction: Joined by vertical butt joints, finished and rolled to smooth surface.
      h. Rolling:
         1) Perform initial or "breakdown" rolling with tandem power roller and follow spreading operation when mixture has reached temperature where it does not "pick up" on rolls.
         2) Keep rolls properly moistened but do not use surplus of water.
         3) Follow initial rolling with pneumatic roller when mixture is in proper condition and when rolling does not cause undue displacement, cracking, or shoving.

4) Begin rolling at sides and progress gradually to center, lapping each preceding track until entire surface has been rolled.
5) Terminate alternate trips of roller in stops at least three feet distant from any preceding stop.
6) At any place not accessible to roller, thoroughly compact mixture with tampers and finish, if necessary, with hot iron to provide uniform layer over entire width being paved.

3. Provide finish surface having uniform texture.

C. Fog sealing:
1. Fog seal asphalt pavement after compaction with fog sealing material applied at rate of 0.05 gallons per square yard at following locations:
a. At locations indicated on the Drawings.

3.03 FIELD QUALITY CONTROL

A. Placement:
1. Place the mixture on the roads, pavements, or walks at a temperature not less than 225 degrees Fahrenheit.

B. Tests:
1. Provide sampling and control testing for the asphalt concrete.
a. The type and size of the samples: Suitable to determine conformance with stability, density, thickness, compaction, and other specified requirements.
b. Use an approved power saw or core drill for cutting samples.
c. Furnish all tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed.
d. Take a minimum 1 sample per 200 tons of asphalt concrete placed.

C. Inspection:
1. Asphalt concrete:
a. Test with a 10-foot straightedge laid on the surface parallel with the centerline of the road: Variation of the surface from the testing edge of the straightedge not to exceed 1/4 inch.

END OF SECTION

SECTION 02821

FENCES AND GATES

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, tools, equipment, and incidentals as required to furnish and install fencing Work as shown on the Drawings and as specified.
   2. Extent of fencing Work is shown on the Drawings and specified herein.
   3. Types of products required include the following:
      a. Aluminum-coated, steel chain link fabric.
      b. Galvanized steel framework.
      c. Welded ornamental steel fence system.
      d. Razor wire.
      e. Auxiliary system components, accessories, fasteners and fittings.

B. Related Sections:
   1. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03300 - Cast-In-Place Concrete.
      b. Section 09960 - High Performance Coatings

1.02 QUALITY ASSURANCE

A. Erector Qualifications:
   1. Engage a single erector skilled, trained and with successful and documented experience, minimum five years, in the installation of fencing, and who is acceptable to the fencing manufacturer. Submit names and qualifications to Engineer along with the following information on a minimum of three successful projects:
      a. Names and telephone numbers of owner, architects, or engineers responsible for projects.
      b. Approximate contract cost of the fencing.
      c. Amount of area installed.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. ASTM A 53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   2. ASTM A 90 - Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
   3. ASTM A 123 - Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. ASTM A 153 - Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

5. ASTM A 428 - Test Method for Weight of Coating on Aluminum-Coated Iron or Steel Articles.
6. ASTM A 491 - Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
7. ASTM A 570 - Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
8. ASTM A 585 - Specification for Aluminum-Coated Steel Barbed Wire.
9. ASTM A 653 - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
10. ASTM A 780 - Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
11. ASTM A 817 - Specification for Metallic-Coated Steel Wire for Chain-Link Fence Fabric.
12. ASTM A 824 - Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
13. ASTM B 6 - Specification for Zinc.
14. ASTM D 412 - Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension.
15. ASTM D 746 - Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
16. ASTM D 792 - Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
17. ASTM D 1499 - Practice for Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics.
18. ASTM D 2240 - Test Method for Rubber Property - Durometer Hardness.
19. ASTM E 329 - Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
20. ASTM E 548 - Guide for General Criteria Used for Evaluating Laboratory Competence.
21. ASTM F 552 - Terminology Relating to Chain Link Fencing.
22. ASTM F 567 - Practice for Installation of Chain-Link Fence.
23. ASTM F 626 - Specification for Fence Fittings.
24. ASTM F 668 - Specification for Poly (Vinyl Chloride) (PVC)-Coated Steel Chain-Link Fence Fabric.
25. ASTM F 900 - Specification for Industrial and Commercial Swing Gates.
26. ASTM F 1043 - Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
27. ASTM F 1083 - Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
28. ASTM F 1184 - Specification for Industrial and Commercial Horizontal Slide Gates.
29. ASTM F 1664 - Specification for Poly (Vinyl Chloride) (PVC)-Coated Steel Tension Wire Used With Chain-Link Fence.
30. ASTM F 1665 - Specification for Poly (Vinyl Chloride) (PVC)-Coated Steel Barbed Wire Used With Chain-Link Fence.
31. ASTM F 2408 - Ornamental Fences Employing Galvanized Steel Tubular Pickets.
32. ASTM G 23 - Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials.
33. Chain Link Fence Manufacturer's Institute (CLFMI), CLF 2445 - Product Manual.

34. Underwriters' Laboratories, Incorporated, Standards for Safety, UL 467, Grounding and Bonding Equipment.
35. The Americans with Disabilities Act of 1990 (Public Law 101-336), Appendix A to Title 28 Code of Federal Regulations Part 36 (Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities - ADAAG).
36. Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments.

C. Testing Agency Qualifications: To qualify for approval, an independent testing agency shall demonstrate to Engineer's satisfaction, based on evaluation of criteria submitted by testing agency, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work, in accordance with ASTM E 329 and as documented according to ASTM E 548.

D. Source Quality Control:
1. Provide fencing as a complete system with all gates, hardware, appurtenances, and other components produced by a single manufacturer, including custom erection accessories, fittings, clamps and fastenings as may be necessary or required. Provide components, devices and accessories from a single manufacturer regularly engaged in the manufacture of such items, acceptable to, and coordinated by, fencing manufacturer as part of fencing manufacturer's Shop Drawing submittal.
2. Provide fence fabric imprinted with manufacturer's trade name, core wire gauge, and finished outside diameter gauge.
3. Provide shipping list for materials used, endorsed with the manufacturer's voucher certifying that the material used in the fencing complies with this Section and with specific selections made on approved Shop Drawings.
4. Structural shapes of satisfactory sections and equal strengths may be substituted if approved by Engineer.

E. Performance Criteria:
1. Comply with the standards of the Chain Link Fence Manufacturer's Institute for product and installation requirements and the requirements of ASTM F 567. These standards shall represent a minimum level of quality when additional information is not shown on the Drawings or specified in the Contract Documents.
2. The requirements of this Section shall conform to MAG Standard Specifications 420, 771 and 772, except as modified, added to, or changed herein. Where there is a conflict between MAG Standard Specification and this Section, the provision of this Section shall apply.
3. Where proposed fencing framework or other structural components varies from Contract Documents, the fabricator shall provide structural calculations for the design of the proposed fencing to Contractor for submittal to Engineer as part of Shop Drawing review. Structural analysis shall verify that all system components including, but not limited to, supports, gates, fasteners, fittings and connections meet the requirements of the Owner. Such modifications shall be incorporated into the Work only as acceptable to Engineer.
4. Verify size of framing members shown on the Drawings or specified, and submit with Shop Drawings. Member sizes, thicknesses and weights shown on the Drawings or specified shall be considered minimum. Where structural analysis indicates, provide additional members, or increased member size, thickness or weight.

5. Modifications may be made only as necessary to meet site conditions to ensure proper fitting and support of the Work, and only upon submittal of Shop Drawings and receipt of approval by Engineer.
6. Furnish weights of zinc and aluminum coatings on wire and pipe fabrications, in compliance with CLF 2445.

F. Fabrication Tolerances:
1. Fabric, posts, rails, and other supports shall be straight or uniformly curved to provide the profiles shown on the Drawings, to a dimensional tolerance of 1/16-inch in ten feet without warp or rack in the finished installation.

1.03 SUBMITTALS

A. Samples: Submit for approval the following:
1. Each fencing component, fastener, post, rail, support, chain-link fabric and other auxiliary and miscellaneous items labeled with identification as to use and location.
2. Each chain-link fabric material, 6 inches square; and framework members, and typical accessories, each approximately 6 inches long.
3. Full range of manufacturer's standard and custom colors.
4. Engineer's review will be for color and texture only. Compliance with all other requirements is the responsibility of Contractor.

B. Shop Drawings: Submit for approval the following:
1. Copies of manufacturer’s technical product information, specifications and installation instructions for all fencing components.
2. All structural calculations verifying that all system components comply with the requirements of the Specifications.
3. Large-scale details drawn at a scale of 3 inches equals one foot for all connections and gate details.
4. Drawings at a scale of 1/4-inch equals one foot of typical fence assembly, identifying all materials, dimensions, sizes, weights, and finishes of all rails, posts, braces, supports and other fencing components. Show fence heights, and locations of gates. Show gate swing, or other operation, hardware, and accessories. Include plans, elevations, sections, with required installation and operating clearances, and details of post anchorage, attachments, and bracing.
5. Qualifications Data: Submit qualifications data for the following:
    a. Erector.
    b. Test agency.
6. A list of all hardware, fasteners, and accessories.

C. Test Reports: Submit the following:
1. Weight of aluminum coating on wire fabrications in compliance with ASTM A 428.
2. Weight of zinc coating on pipe fabrications in compliance with ASTM A 90.
3. On-Site Test Reports: Indicate and interpret test results for compliance of chain link fence and gate performance requirements.

1.04 DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:
   1. Packaging and marking shall comply with CLF 2445.
   2. Deliver materials in manufacturer's original, unopened packaging with all factory-applied tags, labels and other identifying information intact, legible and accurately representing material approved on Shop Drawings by Engineer.
   3. All boxes, crates, and packages shall be inspected by Contractor upon delivery to the site. Contractor shall notify Engineer if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition, in accordance with manufacturer's instructions.
   4. Deliver materials to the site to ensure uninterrupted progress of the Work.

B. Storage of Materials:
   1. Store all materials under weatherproof cover, off the ground and away from other construction activities.
   2. Do not store material in a manner that would create a humidity chamber. Provide for free movement of air under protective cover and between components of the fencing.

C. Handling of Materials:
   1. Handle material in a manner that is in compliance with product institute standards and that will prevent damaging coatings.

1.05 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions, and then only after arranging to provide temporary utility services according to requirements indicated.
   1. Notify Engineer not less than 14 days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Engineer's written permission.

B. Site Measurements: Take measurements at the site and verify layout information and dimensions for fencing and gates in relation to property surveys and existing conditions.

C. Do not begin installation and erection of the fencing until final grading is completed.

1.06 WARRANTY

A. General Warranty: The special warranties specified in this Article shall not deprive Owner of other rights or remedies Owner may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under the Contract Documents.

B. Special Warranties:
   1. Furnish manufacturer's written ten-year warranty against rusting or corrosion of the metal for steel chain link fencing.
   2. All ornamental fence structural components (i.e. rails, pickets, and posts) shall be warranted within specified limitations, by the manufacturer for a period of 20 years from date of original purchase. Warranty shall cover any defects in material finish, including cracking, peeling, chipping, blistering or corroding.

1.07 MAINTENANCE

A. Extra Materials:
   1. Furnish extra materials from the same manufactured lot as the materials installed.
   2. Provide a minimum of five percent excess over the required amount of fencing components. Pack in cartons and store on the site where directed by the Engineer.

B. Do not provide partial containers or packages of materials. Round-up quantities to furnish only complete, unopened and undamaged containers and packages; with legible labels accurately representing contents of container or package, indicating compliance with approved Samples and Shop Drawings, and matching materials actually installed.
   1. Submit quantities of each system component required for the Work, based on actual purchase order to manufacturer for materials to be used for this Project, with calculations establishing quantity of extra materials to be furnished to Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Chain link fence and gates: One of the following or equal:
   1. Allied Tube and Conduit.
   2. Master-Halco.

B. Ornamental Steel Fence: One of the following or equal:
   1. Ameristar Fence Co.
      a. Montage Industrial, 3 rail, Invincible Style, 8 ft tall
   2. Frontier Fence Co.
      a. Equal to Ameristar product specified above

2.02 MATERIALS

A. General:
   1. Tube sizes specified are nominal outside dimension.
   2. Roll formed section sizes are the nominal outside dimensions.
   3. Wire gauges shall conform to American Steel and Wire Company gauge.
   4. Heat-form all arcs and chords before protective coatings are applied to metal.
   5. All sizes specified are given for uncoated metal. All protective coatings are in addition to specified metal dimensions, gauges, and sizes.

B. Chain-Link Fence Fabric:
   1. One-piece fabric widths, for fencing 12 feet and less in height, complying with CLFMI product requirements.
   2. Wire mesh shall be woven throughout in the form of approximately uniform square mesh with parallel sides and horizontal and vertical diagonals of approximately uniform dimensions, of size and gauge specified and in compliance with ASTM A 817, Type 1, cold-drawn carbon steel wire with minimum breaking strength of 2,170 pounds and coated with aluminized finish,

as specified. Fabric shall be recommended by the Chain Link Fence Manufacturer's Institute for heavy industrial usage.

3. Provide fabric knuckled to eliminate exposure of sharp edges.
4. Fabric Gauge: Provide the following:
   a. No. 9-gauge wires.
5. Mesh Size: Provide the following:
   a. 2-inch mesh maximum.
6. The fabric shall be connected to the line posts with 6-gauge hot dip galvanized wire clips every 14 inches, to terminal, corner, and gateposts by using bars.
7. The fabric shall be connected to stretcher bars using 11-gauge hog rings or tension bands every 24 inches.

C. Ornamental Fence:
   1. Steel material for fence panels and posts shall conform to the requirements of ASTM A 653/A 653M, with a minimum yield strength of 45,000 psi (310 MPa) and a minimum zinc (hot-dip galvanized) coating weight of 0.90 oz/ft^2 (276 g/m^2), Coating Designation G-90.
   2. Material for pickets shall be 1" square x 16 Ga. tubing. The rails shall be steel channel, 1.75" x 1.75" x 0.105". Picket holes in the rail shall be spaced 4.715" o.c. Fence posts and gate posts shall meet the minimum size requirements of the manufacturer.

2.03 FRAMEWORK

A. General: The following table is provided for the convenience of Contractor and provides actual OD and equivalent nominal NPS size and trade size of round members.

Actual OD (inches)	NPS Size (inches)	Trade Size (inches)
1.315	1	1-3/8
1.660	1-1/4	1-5/8
1.900	1-1/2	2
2.375	2	2-1/2
2.875	2-1/2	3
3.500	3	3-1/2
4.000	3-1/2	4
6.625	6	6-5/8
8.625	8	8-5/8

B. Pipe shall be commercial grade, plain end steel pipe with standard weight walls. Steel strip used in the manufacture of pipe shall be in compliance with ASTM F 1083, Schedule 40 pipe with minimum yield strength of 25,000 pounds per square inch and protected with zinc, as specified.

C. End, Corner, and Pull Posts: Provide end, corner, and pull posts of minimum sizes as follows:
   1. Over Six Feet Fabric Height:
      a. 2.875 inches OD pipe weighing 5.79 pounds per linear foot.

2. Over Eight Feet Fabric Height:
    a. 3.50 inches OD pipe weighing 7.58 pounds per linear foot.

D. Line Posts: Provide line posts of the minimum sizes and weights as follows:
1. Over Six Feet Fabric Height:
    a. 2.375 inches OD pipe weighing 3.65 pounds per linear foot.
2. Over Eight Feet Fabric Height:
    a. 3.50 inches OD pipe; weight of 7.58 pounds per linear foot.

E. Gate Posts: Furnish gateposts for supporting single gate leaf, or one leaf of a double gate installation, for nominal gate widths as follows:
1. Up to Six Feet Wide:
    a. 2.875 inches OD pipe weighing 5.79 pounds per linear foot.
2. Over Six Feet and Up To 13 Feet Wide:
    a. 4 inches OD pipe weighing 9.11 pounds per linear foot.
3. Over 13 Feet and Up To 18 Feet Wide:
    a. 6.625 inches OD pipe weighing 18.97 pounds per linear foot.
4. Over 18 Feet:
    a. 8.625 inches OD pipe weighing 28.55 pounds per linear foot.

F. Top and Bottom Rails: Provide top and bottom rails, unless otherwise shown on the Drawings, of the following:
1. 1.900-inch OD pipe weighing 2.72 pounds per linear foot.
2. Provide in manufacturer's longest lengths, with expansion type coupling 0.051-inch thick rail sleeves, approximately 7 inches long, for each joint.
3. Provide means for attaching the top and bottom rails securely to each gate, corner, pull, and end post.

G. Roll-Formed Steel: Provide rolled steel shapes produced from structural-quality steel conforming to ASTM A 570, Grade 45, with a minimum yield strength of 45,000 pounds per square inch. Protective coating system shall conform to ASTM F 1043, as specified.

2.04 GATES

A. Swing gates shall comply with the requirements of ASTM F 900.

B. Sliding chain link gates shall comply with the requirements of ASTM F 1184.

C. Gate hinges shall be of the double clamping offset type. To hold the gate in the open or closed positions, provide each gate frame with a keeper that automatically engages a gate shoe set in concrete. Gates shall have a drop latch with provision for a padlock.
1. Gate Hinges: Pressed or forged steel or malleable iron to suit gate size, non lift off type, 180 degree offset heavy-industrial hinges; one pair per leaf.
2. Latch: Forked-type or plunger bar type to permit operation from either side of gate, with padlock eye as integral part of latch.
3. Keeper: Provide a gatekeeper for vehicle gates that automatically engages gate leaf and holds it in the open position until manually released.

D. All gate frames shall have intermediate horizontal rails. Gate frames shall be of welded construction and shall be galvanized after fabrication. Single gates six feet

wide or wider and double gates 12 feet wide or wider shall be provided with diagonal bracing in one direction, extending from top to bottom rail.

E. Gate Stops: Provide gate stops for double gates consisting of mushroom-type flush plate with anchors, set in concrete, and designed to engage a center drop rod or plunger bar. Include locking device and padlock eyes as an integral part of the latch, using one padlock for locking both gate leaves.

F. Fabricate gate perimeter frames of tubular members. Provide additional horizontal and vertical members for proper gate operation and for attachment of fabric, hardware and accessories. Space so that frame members are not more than eight feet apart. Fabricate as follows:
   1. Over six feet high, or leaf width exceeding eight feet:
      a. 1.900-inch OD pipe weighing 2.72 pounds per linear foot.

G. Assemble gate frames by welding. Install fabric with stretcher bars at vertical edges. Bars may also be used at top and bottom edges. Attach stretchers to gate frame at not more than 15 inches on center. Attach hardware with rivets or by other means that will provide security against removal or breakage.

H. Install diagonal cross bracing on gates consisting of 1/2-inch diameter adjustable length truss rods provided with turnbuckles for frame rigidity without sag or twist.

I. Where razor wire is shown on the Drawings above gates, extend the end members of gate frames 1 foot 0 inch above the top member and prepare to receive three strands of wire. Provide necessary clips for securing wire to extensions.

2.05 AUXILIARY FENCING MATERIALS AND ACCESSORIES

A. Wire Ties:
   1. For tying fabric to line posts, use 9-gauge, aluminum alloy 1100-H4, steel wire ties to match fence fabric, spaced 12 inches on center.
   2. For tying fabric to rails and braces, use 9-gauge, aluminum alloy 1100-H4, steel wire ties to match fence fabric, spaced 24 inches on center.
   3. For tying fabric to tension wire, use 11-gauge, aluminum alloy 1100-H4, steel wire hog ring ties to match fence fabric, spaced 24 inches on center.

B. Tension Wire: Provide tension wire consisting of aluminized, 7-gauge, coiled spring steel wire coated with 0.40 ounce of aluminum per square foot of wire surface, minimum, in compliance with ASTM F1664.
   1. Locate at bottom and top of fabric.

C. Razor Wire Supporting Arms: Pressed steel for coils of razor wire attached to each arm, complete with provisions for anchorage to posts. Supporting arms shall be integral with post top weather cap. Provide following type:
   1. Single 45-degree arm, one for each post.

D. Razor Wire: Stainless steel, 0.025 inch thick x 1 inch wide, coil diameter of 18 inches, die stamped to produce 4 barbed points at 4 inches on center; cold clench over stainless steel core.

E. Post Caps: Pressed steel, wrought iron, or cast aluminum alloy, designed as a weathertight closure cap, for tubular posts. Provide one cap for each post, unless

equal protection is afforded by combination post top cap and barbed wire supporting arm, where barbed wire is required.
1. Provide caps with openings to permit through passage of the top rail.
2. Provide cone-type caps for terminal posts and loop-type caps for line posts.

F. Stretcher Bars: One-piece lengths equal to full height of fabric, with a minimum cross section of 3/16-inch by 3/4-inch. Provide one stretcher bar for each gate and end post, and two for each corner and pull post, except where fabric is integrally woven into the post.

G. Stretcher Bar Bands: Pressed steel, hot dipped galvanized, 0.078 inch to 0.108 inch thick depending on post diameter, spaced not over 15 inches on center to secure stretcher bars to end, corner, pull, and gate posts.
1. Bands may also be used with special fittings for securing rails to end, corner, pull, and gateposts.

H. Truss Rods: Steel rods, 3/8-inch diameter, merchant quality with turnbuckle.

I. Concrete: Refer to Section 03300, Cast-In-Place Concrete.

2.06 FABRICATION OF ORNAMENTAL FENCE

A. Pickets, rails and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets.

B. Pickets shall be inserted into the pre-punched holes in the rails and shall be aligned to standard spacing using a specially calibrated alignment fixture. The aligned pickets and rails shall be joined at each picket-to-rail insertion by welding process.

C. The manufactured panels and posts shall be subjected to an inline electrodeposition coating (E-Coat) process consisting of a multi-stage pretreatment/wash (with zinc phosphate), followed by a duplex application of an epoxy primer and acrylic topcoat. The minimum cumulative coating thickness of epoxy and acrylic shall be 2 mils (0.058 mm). The color shall be black. The coated panels and posts shall be capable of meeting the performance requirements of the manufacturer.

D. The manufactured fence system shall be capable of meeting the vertical load, horizontal load, and infill performance requirements for industrial weight fences under ASTM F 2408.

2.07 FINISHES

A. Chain-Link Fence Fabric:
1. Aluminized finish with not less than 0.40-ounces aluminum per square foot, complying with ASTM A 491, Class II.

B. Framework and Appurtenances: Provide the following finishes for steel framework, auxiliary system components and miscellaneous accessories:
1. Galvanizing: Zinc for galvanizing shall be of High Grade or Special High Grade conforming to ASTM B6 with a maximum aluminum content of 0.01 percent. Galvanize metal by the "hot-dip" process in compliance with the following standards:
a. Structural Iron and Steel Shapes: ASTM A 123.

b. Rolled-Form Sheet Steel: ASTM A 653.
c. Hardware and Accessories: ASTM A 153.
d. Fittings: ASTM F 626.
e. Pipe: ASTM A 53.

2. Provide minimum weights of zinc as follows:
a. Pipe: 1.8-ounces of zinc per square foot. Type A coating shall be applied both inside and outside according to ASTM F 1043, as determined by ASTM A 90.
b. Rolled-Form Sheet Steel: 4.0-ounces of zinc per square foot of surface area.
c. Hardware and Accessories: Zinc weights in compliance with Table 1 of ASTM A 153.

C. Welded Joints:
1. Repair zinc coatings at welded joints by applying a zinc-rich paint, as specified in Section 05120, Section 3.02, Structural Steel.

D. Ornamental Steel Fence:
1. See Section 2.06

PART 3 EXECUTION

3.01 INSPECTION

A. Contractor shall examine the conditions under which the fencing and gates are to be erected and notify Engineer, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to Engineer.

3.02 PREPARATION

A. Do not begin fence installation and erection before the final grading is completed with finish elevations established.

3.03 INSTALLATION AND ERECTION FOR CHAIN LINK FENCE

A. Unless otherwise shown on the Drawings, install chain link fence system according to MAG Section 420.3.1, 420.3.2, and 420.3.3.

B. Excavation: Drill holes of diameters specified, for post footings in firm, undisturbed, or compacted soil.
1. For posts set in cast-in-place concrete, provide hole diameters dug or drilled a minimum of four times the largest cross section of the post.
a. Unless otherwise shown on the Drawings, excavate hole depths approximately 3 inches lower than the post bottom, with bottom of posts set not less than 24 inches below the surface of finished grade when in firm, undisturbed soil, plus an additional 3 inches for each foot increase in the fence height over four feet.
b. Excavate holes for sliding cantilever gateposts to not less than 3 feet 6 inches below grade and minimum diameter of 12 inches.
2. Spread soil from excavations uniformly adjacent to the fence line, or on adjacent areas of the site, as directed by the Engineer.

3. When solid rock is encountered at the surface, drill into rock at least 12 inches for line posts and at least 18 inches for end, pull, corner, and gateposts. Drill hole at least 1 inch greater diameter than the largest dimension of the post to be placed.
    a. If solid rock is below soil overburden, drill to full depth required, except penetration into rock need not exceed the minimum depths specified above.

C. Setting Posts: Remove loose and foreign materials from sides and bottoms of holes, and moisten soil prior to placing concrete.
1. Center and align posts in holes 3 inches above bottom of excavation.
2. Posts shall be set in concrete footings, except as otherwise shown on the Drawings or specified. Place concrete around posts in a continuous pour, and vibrate or tamp for consolidation. Check each post for vertical and top alignment, and hold in position during placement and finishing operations.
3. Extend concrete to 2 inches above grade or to 2 inches below grade if a cover of sod, blacktop, or other material is shown to conceal concrete. Crown to shed water away from posts.
4. Extend footings for gateposts to the underside of bottom hinge. Set keeps, stops, sleeves and other accessories into concrete as required.
5. Keep exposed concrete surfaces moist for at least seven days after placement, or cure with membrane curing materials, or other acceptable curing method.
6. Grout posts set in sleeved holes, concrete constructions, or rock with grout, as specified in Section 03600, Grout, and as recommended by CLF 2445.

D. Concrete: Provide concrete consisting of portland cement complying with ASTM C 150, aggregates complying with ASTM C 33, and clean water. Mix materials to obtain concrete with a minimum 28-day compressive strength 2,500 pounds per square inch, using at least four sacks of cement per cubic yard, 1 inch maximum size aggregate, maximum 3-inch slump, and 2-percent to 4-percent entrained air.

E. Concrete Strength: Allow concrete to attain at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than seven days after placement, before rails, tension wires, barbed wire, or chain-link fabric is installed.
1. Do not stretch tension fabric and wires, and do not hang gates until the concrete has attained its full design strength.

F. Posts and Rails:
1. Line Posts: Set posts in cast-in-place concrete footings as specified, spaced not more than ten feet on centers. Install caps on tops of all posts to exclude moisture and to receive the top rail unless equal protection is afforded by combination post top cap and barbed wire supporting arm, where barbed wire is required.
2. Top Rails: Run rail continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by fencing manufacturer to form a continuous rail between terminal posts.
3. Brace Assemblies: Install braces so posts are plumb when diagonal rod is under proper tension. Install brace assemblies at end posts and at both sides of corner and pull post panels. Panels adjacent to gates shall have

intermediate horizontal rails and diagonal bracing. The diagonal bracing shall run from the center of the first line post to the bottom of the terminal post.

G. Chain-Link Fabric:
   1. Install fabric on security side of fence, and anchor to framework so that fabric remains in tension after pulling force is released. Fasten to terminal posts and gateposts with tension bars threaded through mesh and secured with tension bands at maximum intervals of 14 inches.
   2. Tie to line posts, gate frames, and top and bottom rails with tie wires spaced at maximum 12 inches on posts and 24 inches on rails.
   3. Connect tension bars to posts and frames by means of adjustable bolts and bands spaced not more than 14 inches apart.
   4. Leave approximately 2 inches between finish grade and bottom selvage, except where bottom of fabric extends into concrete.
   5. Join roll of chain-link fabric by weaving a single picket into the ends of the roll to form a continuous mesh.

H. Tension Wire:
   1. Stretch tension wire taut and free of sag, from end to end of each stretch of fence and position at a height that will enable the wire to be fastened to the chain-link fabric by securing within the top 12 inches of the chain-link fabric.
   2. Fasten bottom tension wire within the bottom 6 inches of the chain-link fabric.
   3. Tie tension wire to each post with not less than 6-gauge galvanized wire.

I. Razor Wire:
   1. Install 18-inch diameter loop razor wire with stainless steel core in accordance with manufacturer's instructions.
   2. Secure wire to terminal posts utilizing terminal post band arms or brace bands.
   3. Extend vertical members of gates to receive the razor wire.

J. Stretcher Bars: Thread through or clamp to fabric 4 inches on center, and secure to posts with metal bands spaced 15 inches on center.

K. Gates: Install gates plumb, level, and secure for full opening without interference. Install ground set items in concrete for anchorage, as shown on approved Shop Drawings. Adjust hardware for smooth operation and lubricate where necessary.

L. Tie Wires: Use U shaped wires conforming to diameter of pipe. Clasp pipe and fabric firmly with ends twisted at least two full turns. Bend ends of wire to minimize hazard to persons or clothing.

M. Fasteners: Install nuts for tension band and hardware bolts on side of fence opposite fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

3.04 INSTALLATION AND ERECTION FOR ORNAMENTAL FENCE

A. Preparation: All new installation shall be laid out by the contractor in accordance with the construction plans.

B. Fence Installation: Fence posts shall be spaced according to manufacturer specifications. For installation that must be raked to follow sloping grades, the post spacing dimension must be measured along the grade. Fence Panels shall be attached to posts with brackets supplied by the manufacturer. Posts shall be set in

concrete footers having a minimum depth of 36”. The Earthwork and Concrete sections of these Specifications shall govern material requirements for the concrete footer. Posts setting by other methods such as plated posts or grouted core-drilled footers are permissible only if shown by engineering analysis to be sufficient in strength for the intended application.

C. Gate Installation: Gate posts shall be spaced according to the manufacturers’ gate drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected. The manufacturers’ gate drawings shall identify the necessary gate hardware required for the application. Gate hardware shall be provided by the manufacturer of the gate and shall be installed per manufacturer’s recommendations.

D. Installation Maintenance: When cutting/drilling rails or posts, adhere to the following steps to seal the exposed steel surfaces:
   1. Remove all metal shavings from cut area.
   2. Apply zinc-rich primer to thoroughly cover cut edge and/or drilled hole; let dry.
   3. Apply 2 coats of custom finish paint matching fence color.

   Failure to seal exposed surfaces per steps 1-3 above will negate warranty.

3.05 ADJUSTMENT AND CLEANING

A. Repair coatings damaged in the shop or during erection on-site by recoating with manufacturer's recommended repair compound, applied in accordance with manufacturer's directions.

B. Gate: Adjust gate to operate smoothly, easily, and quietly, free from binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

C. Lubricate operating equipment and clean exposed surfaces.

D. Repair and replace all broken or bent components.

END OF SECTION

SECTION 02952

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02722 - Aggregate Base Courses.
      b. Section 02742 - Asphaltic Concrete Paving.
      c. Section 03300 - Cast-in-Place Concrete.

1.02 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Limiting dimensions:
      a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
      b. Join existing surfaces to terminals of new surfacing in smooth juncture.

1.03 SUBMITTALS

A. Mix designs:
   1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
   2. Submit gradation of aggregate base.
   3. Submit proposed mix design of portland cement concrete.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aggregate base course: As specified in Section 02722.

B. Asphalt pavement: As specified in Section 02742.

C. Portland cement concrete replacement material: Class A concrete as specified in Section 03300.

2.02 EQUIPMENT

A. Roads, pavements, parking areas, and walks:
   1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

2.03 ACCESSORIES

A. Material for painting asphalt concrete pavement: Tack coat as specified in Section 02742.

PART 3 EXECUTION

3.01 INSTALLATION

A. Aggregate surface removal replacement:
   1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.

B. Pavement removal and temporary asphalt replacement:
   1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
   2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
   3. Remove and dispose of temporary paving from project site.
   4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
   5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.

C. Asphalt pavement replacement:
   1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
   2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.

3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and all costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
4. Conform replacement of asphalt pavement to contour of original pavement.

D. Portland cement concrete pavement replacement:
1. Where trenches lie within portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.
2. Place portland cement concrete replacement material to dimension as indicated on the Drawings.
3. Provide expansion joints that match existing.
4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
5. Surface finish: Wood float finish.

E. Curb, gutter, and sidewalk replacement:
1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
a. Provide expansion joints of same spacing and thickness as original construction.

F. Asphalt pavements:
1. Trim existing asphalt pavements which are to be matched by pavement widening or pavement extension to neat true line with straight vertical edges free from irregularities with saw specifically designed for this purpose. Minimum allowable depth of cut shall be 1-1/2 inches.
2. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement widening or extension, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt concrete pavements.
3. No extra payment will be made for these items and all costs incurred in performing this work shall be incidental to widening or pavement extension.

3.02 FIELD QUALITY CONTROL

A. Tests:
1. Asphalt concrete as specified in Section 02742.
2. Concrete as specified in Section 03300.

B. Inspection:
   1. Asphalt concrete:
      a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
      b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
   2. Portland cement concrete replacement pavement:
      a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.
      b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 03055

EPOXY BONDING REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in concrete using epoxy adhesive.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 03200 - Concrete Reinforcing.
      c. Section 05120 - Structural Steel.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

B. ASTM international (ASTM):
   1. C 881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

C. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

D. Society for Protective Coatings (SSPC):
   1. Surface Preparation Standards (SP)
      a. SP-1 - Solvent Cleaning.

1.03 SUBMITTALS

A. Product Data: Furnish technical data for epoxy adhesives, including:
   1. Installation instructions.
   2. Independent laboratory test results.
   3. Handling and storage instructions.

B. Quality control submittals:
   1. Epoxy manufacturer's past project experience data on at least 3 similar projects supplied with proposed products within the last 3 years.
   2. Special inspection: Provide detailed step-by-step instructions for the special inspection procedure in accordance with the building code as specified in Section 01410.
   3. ICC Evaluation Service, Inc., Evaluation Services Report in compliance with the AC308-Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection.
   1. Store epoxy components on pallets or shelving in a covered-storage area.
   2. Control temperature above 60 degrees Fahrenheit and dispose of product if shelf life has expired.
   3. If stored at temperatures below 60 degrees Fahrenheit, test components prior to use to determine if they still meet specified requirements.

1.05 PROJECT CONDITIONS

A. Seismic design category: B.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

2.02 EPOXY ADHESIVE FOR SELF-CONTAINED CARTRIDGE SYSTEM

A. Epoxy adhesive shall have a current ICC Evaluation Service report documenting acceptance under AC308 for use with cracked concrete and for the seismic design categories specified.

B. Materials:
   1. In accordance with ASTM C 881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture, and gray in color.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

C. Packaging:
   1. Furnished in side-by-side cartridges with resin and hardener components isolated until mixing through manufacturer’s static mixing nozzle. Nozzle designed to thoroughly blend the components for injection from the nozzle directly into prepared hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

D. Manufacturers: One of the following or equal:
   1. Hilti, Inc., Tulsa, OK: RE 500-SD.
   2. Simpson Strong-Tie Company, Inc., Pleasanton, CA: SET-XP.

2.03 ALL THREAD RODS

A. Materials: As specified in Section 05120.

2.04 REINFORCING BARS

A. As specified in Section 03200.

PART 3 EXECUTION

3.01 GENERAL

A. Provide epoxy adhesive packaged as follows:
   1. Disposable, self-contained cartridge system capable of dispensing both epoxy components in the proper mixing ratio, and fit into a manually or pneumatically operated caulking gun.
   2. Dispense components through a mixing nozzle that thoroughly mixes components.

3.02 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a “condition of use” in the ICC Evaluation Report submitted.
   3. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.
   4. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

C. Hole diameter: Reinforcing bar diameter or all thread rod diameter plus 1/8 inch.

D. Obstructions in drill path:
   1. If an existing reinforcing bar or other obstruction is hit while drilling hole, stop drilling hole and fill the hole with drypack mortar. Relocate the hole to miss the obstruction and drill another hole. Repeat the above until the hole has been drilled to the required depth.
   2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the structural member and endanger the stability of the structure. Drypack holes which hit obstructions and allow

drypack to reach strength equal to the existing concrete before drilling adjacent holes. Epoxy grout may be substituted for drypack when acceptable to Engineer.

3. When existing reinforcing steel is encountered during drilling and when acceptable to Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter.
4. Bent bar reinforcing bars: Where edge distances are critical, and striking reinforcing steel is likely, and if acceptable to Engineer, drill hole at 10 degree angle or less from axis of reinforcing bar or all thread rod being installed.

E. Install reinforcing bars and all thread rods to depth, spacings, and locations as indicated on the Drawings.
   1. Do not install epoxy bonded all-thread rods or reinforcing bars in overhead applications.

F. Cleaning holes:
   1. Insert long air nozzle into hole and blow out loose dust. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
   2. Use a stiff bristle brush to vigorously brush hole to dislodge compacted drilling dust.
   3. Repeat step 1.
   4. Repeat above steps as required to remove drilling dust or other material that will reduce bond. The hole shall be clean and dry.

G. Cleaning reinforcing bars and all thread rods:
   1. Solvent clean reinforcing bar and all thread rods over the embedment length in accordance with SSPC SP-1 Solvent Cleaning. Provide an oil and grease free surface to promote bonding of adhesive to steel.
   2. Clean reinforcing bars and all thread rods over embedment length to bare metal. The reinforcing bars and all thread rods shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.

H. Filling hole with epoxy:
   1. Fill hole with epoxy before inserting the reinforcing bar or all thread rod. Fill hole with epoxy starting from bottom of hole. Fill hole without creating air voids.
   2. Fill hole with sufficient epoxy so that excess epoxy is extruded out of the hole when the reinforcing bar or all thread rod is inserted into the hole.
   3. Do not install epoxy prior to receiving epoxy manufacturer's onsite training.

3.03 MANUFACTURERS' SERVICES

A. Furnish manufacturer's representative to conduct jobsite training for proper installation, handling, and storage of epoxy, for personnel who will perform actual installation. Engineer may attend training sessions.

END OF SECTION

SECTION 03071

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

B. Related Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 638 - Standard Test Method for Tensile Properties of Plastics.
   2. D 695 - Standard Test Method for Compressive Properties of Rigid Plastics.
   3. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:
   1. Provide epoxy materials that are new and use them within shelf life limitations set forth by manufacturer.
   2. Perform and conduct work of this Section in neat orderly manner.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's data completely describing epoxy materials.

B. Quality Control Submittals:
   1. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Epoxy: Water-insensitive 2-part type low viscosity epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified: Manufacturers: One of the following or equal:
   1. BASF, MBT, Concresive® Standard LVI.
   2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.

Physical Characteristic	Test Method	Required Results
Tensile Strength	ASTM D 638	8,000 pounds per square inch minimum at 14 days and 77 degrees Fahrenheit cure.
Flexure Strength	ASTM D 790	11,000 pounds per square inch minimum at 14 days and 77 degrees Fahrenheit cure.
Compressive Strength	ASTM D 695	16,000 pounds per square inch minimum at 24 hours and 77 degrees Fahrenheit cure.
Bond Strength	--	Concrete shall fail before failure of epoxy.
Gel Time for 5 Mil Film	--	Four hours maximum at 77 degrees Fahrenheit.
Elongation	ASTM D 638	1 percent minimum at 14 days and 77 degrees Fahrenheit.

B. Epoxy Gel: Manufacturers: The following or equal:
   1. Sika Chemical Corp., Sikadur 31, Hi-Mod Gel.

C. Epoxy Bonding Agent: Manufacturers: One of the following or equal:
   1. BASF, MBT, Concresive® Liquid LPL.
   2. Sika Chemical Corp., Sikadur 32, Hi-Mod LPL.
   3. If increased tack time is required for concrete placement, epoxy resin - portland cement bonding agent as specified in Section 03072 may be used instead of epoxy bonding agent.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with manufacturer's installation instructions.

C. Epoxy Gel:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy Bonding Agent:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Bonding agent will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 03072

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy resin/portland cement bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   2. C 348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   3. C 496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C 882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sika Corporation, Lyndhurst, New Jersey, Sika Armatec 110.

B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
   1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
   2. Documented proof that the proposed substitute product has a 1-year proved record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

2.02 MATERIALS

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.
   2. Component "B" shall be primarily a water solution of a polyamine.

3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

2.03 PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin/portland cement adhesive:
   1. Pot life: 75 to 105 minutes.
   2. Contact time: 24 hours.
   3. Color: Dark gray.

B. Properties of the cured epoxy resin/portland cement adhesive:
   1. Compressive strength in accordance with ASTM C 109:
      a. 3 day: 4,500 pounds per square-inch minimum.
      b. 7 days: 6,500 pounds per square-inch minimum.
      c. 28 days: 8,500 pounds per square-inch minimum.
   2. Splitting tensile strength in accordance with ASTM C 496:
      a. 28 days: 600 pounds per square-inch minimum.
   3. Flexural strength:
      a. 1,100 pounds per square-inch minimum in accordance with ASTM C 348.
   4. Bond strength in accordance with ASTM C 882 modified at 14 days:
      a. 0 hours open time: 2,800 pounds per square-inch minimum.
      b. 24 hours open time: 2,600pounds per square-inch minimum.
   5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
   6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA/RD86/193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry, mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only that quantity that can be applied within its pot life.

B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper type" spray equipment:
      a. For hand applications: Place fresh, plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

SECTION 03102

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete formwork.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03300 - Cast-in-Place Concrete.
      b. Section 03600 - Grouts.
      c. Section 07900 - Joint Sealers.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.

B. ASTM International (ASTM):
   1. A 82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   2. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Design of concrete forms, falsework, and shoring in accordance with local, state, and federal regulations.
   2. Design forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.

B. Performance requirements:
   1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.
   3. Provide sufficient number of forms so that the work may be performed rapidly and present uniform appearance in form patterns and finish.

1.04 SUBMITTALS

A. Information on the Contractor's proposed forming system: Submit in such detail as the Engineer may require to assure himself that intent of the Specifications can be complied with by use of proposed system.

B. Alternate combinations of plywood thickness and stud spacing: May be submitted.

C. Proposed “Starter Wall” detail if different from one shown on structural drawings.

1.05 PROJECT CONDITIONS

A. Requirements due to weather condition:
   1. Removal of formwork: Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until concrete has attained specified strength as determined by test cylinders stored in field under equivalent conditions as concrete structure.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Form ties:
   1. General:
      a. Provide form ties for forming system selected that are manufactured by recognized manufacturer of concrete forming equipment.
      b. Do not use wire ties or wood spreaders of any form.
      c. Provide ties of type that accurately tie, lock, and spread forms.
      d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2 inches of the surface of the concrete.
      e. Do not allow holes in forms for ties to allow leakage during placement of concrete.
   2. Cone-snap ties:
      a. Cone-snap ties shall form a cone shaped depression in the concrete with a minimum diameter of 1 inch at the surface of the concrete and 1-1/2 inches deep.
      b. Provide neoprene waterseal washer that is located near the center of the concrete.
   3. Taper ties:
      a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickeners.
      b. Dry-pack mortar for filling taper tie holes:
         1) Consist of mix of 1 part of portland cement to 1 part of plaster sand.
         2) Amount of water to be added to cement-sand mix is to be such that mortar can be driven into holes and be properly compacted.
         3) Admixtures or additives: Are not to be used in dry-pack mortar.

B. Built-up plywood forms:
   1. Built-up plywood forms may be substituted for prefabricated forming system subject to following minimum requirements:
      a. Size and material:
         1) Full size 4- by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
         2) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
      b. Wales: Minimum 2- by 4-inch lumber.
      c. Studding and wales: Contain no loose knots and be free of warps, cups, and bows.

C. Steel or steel framed forms:
   1. Steel forms: Provide forms that are:
      a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
      b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
   2. Steel framed plywood forms:
      a. Provide forms that are rigidly constructed and capable of being braced.
      b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.

PART 3 EXECUTION

3.01 EXAMINATION

A. Site verification of conditions:
   1. Do not place any concrete until all forms have been thoroughly checked for alignment, level, strength, and to assure accurate location of all mechanical and electrical inserts or other embedded items.

3.02 INSTALLATION

A. Forms and accessories:
   1. Vertical forms:
      a. Remain in place minimum of 24 hours after concrete is placed.
      b. If, after 24 hours, concrete has sufficient strength and hardness to resist surface or other damage, forms may be removed.
   2. Other forms supporting concrete and shoring: Remain in place as follows:
      a. Sides of footings: 24 hours minimum.
      b. Vertical sides of beams, girders, and similar members: 48 hours minimum.
      c. Slabs, beams, and girders: Until concrete strength reaches specified strength f'_c or until shoring is installed.
      d. Shoring for slabs, beams, and girders: Shore until concrete strength reaches specified strength.
      e. Wall bracing: Brace walls until concrete strength of beams and slabs laterally supporting wall reaches specified strength.

3. Green concrete:
    a. No heavy loading on green concrete will be permitted.
    b. Green concrete is defined as concrete with less than 100 percent of specified strength f'_c.
4. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified in Section 03300.

B. Form ties:
1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally. After forms are removed from wall, fill tie holes as follows:
    a. Remove form ties from surfaces.
    b. Roughen cone shaped tie holes by heavy sandblasting before repair.
    c. Dry pack cone shaped tie holes with dry-pack mortar as specified in Section 03600.
2. Taper ties:
    a. After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:
        1) Heavy sandblast and then clean tie holes.
        2) After cleaning, drive neoprene plug into each of taper tie holes with steel rod. Final location of neoprene plug shall be in center third of wall thickness. Bond neoprene plug to concrete with epoxy.
        3) Locate steel rod in cylindrical recess, made in plug, during driving.
            a) At no time are plugs to be driven on flat area outside cylindrical recess.
    b. Dry-pack of taper tie holes: After installing plugs in tie holes:
        1) Coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03600.
            a) Dry-pack mortar: Place in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
            b) Dry-pack the outside of the hole no sooner than 7 days after the inside of the hole has been dry packed.
            c) Wall surfaces in area of dry-packed tie holes: On the water side of water containing structures and the outside of below grade walls:
                (1) Cover with minimum of 10 mils of epoxy gel.
                (2) Provide epoxy gel coating on wall surfaces that extend minimum of 2 inches past dry-pack mortar filled tie holes.
                (3) Provide finish surfaces that are free from sand streaks or other voids.

C. Built-up plywood forms:
1. Studding:
    a. Spaced at 16 inches or 24 inches on center.
    b. Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
    c. Install studs perpendicular to grain of exterior plys of plywood sheets.
2. Wales: Form wales of double lumber material with minimum size as specified in this Section.

3. Number of form reuses: Depends upon durability of surface coating or overlay used, and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.

D. Steel or steel framed forms:
   1. Steel forms:
      a. Adequately brace forms for minimum deflection of finish surface.
   2. Steel framed plywood forms:
      a. Rigidly construct and brace with joints fitting closely and smoothly.
      b. Number of form reuses: Depends upon durability of surface coating or overlay used.
   3. Built-up plywood forms: As specified in this Section may be used in conjunction with steel forms or steel framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.

E. Bracing and alignment of forms:
   1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
   2. Formwork:
      a. Securely brace, support, tie down, or otherwise hold in place to prevent any movement.
      b. Make adequate provisions for uplift pressure, lateral pressure on forms, and deflection of forms.
   3. When second lift is placed on hardened concrete: Take special precautions in form work at top of old lift and bottom of new lift to prevent:
      a. Spreading and vertical or horizontal displacement of forms.
      b. Grout "bleeding" on finish concrete surfaces.
   4. Pipe stubs, anchor bolts, and other embedded items: Set in forms where required.
   5. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.

3.03 CONSTRUCTION

A. Tolerances:
   1. Finish concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. The maximum deviation from true line and grade shall not exceed tolerances listed below at time of acceptance of project.
   3. General: In accordance with ACI 117, paragraphs 2.1 through 2.2 and paragraphs 4.0 through 4.6, except as modified in following:
      a. Slabs:
         1) Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
         2) Slabs indicated to be level: Have maximum deviation of 1/8-inch in 10 feet without any apparent changes in grade.
      b. Walls:
         1) Top elevation: Within 1/4 inch (plus or minus).
         2) Alignment at top: Within 1/4 inch (plus or minus).

c. Inserts: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
d. Maximum tolerances: As follows:

Item	Tolerance
Sleeves and Inserts	Plus 1/8 Minus 1/8 inch
Projected Ends of Anchor Bolts	Plus 1/4 Minus 0.0 inch
Anchor Bolt Setting	Plus 1/16 Minus 1/16 inch

END OF SECTION

SECTION 03150

CONCRETE ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Polyvinyl chloride waterstop.
   2. Preformed synthetic sponge rubber expansion joint material.
   3. Preformed bituminous fiber expansion joint material.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 570 - Standard Test Method for Water Absorption of Plastics.
   2. D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
   3. D 638 - Standard Test Method for Tensile Properties of Plastics.
   4. D 746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
   5. D 747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
   6. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. D 2240 - Standard Test Method for Rubber Property - Durometer Hardness.

B. U. S. Army Corps of Engineers (USACE):
   1. CRD-C-572, Specification for Polyvinyl Chloride Waterstop.

1.03 SUBMITTALS

A. Product data:
   1. Polyvinyl chloride waterstops: Complete physical characteristics.
   2. Preformed expansion joint material: Sufficient information on each type of material for review to determine conformance of material to requirements specified.

B. Samples:
   1. Polyvinyl chloride waterstop.

C. Laboratory test reports: Indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.

D. Quality control submittals:
   1. Certificates of Compliance:
      a. Written certificates that polyvinyl chloride waterstops supplied on this Project meet or exceed physical property requirements of current USACE CRD-C-572 and the requirements of this Section.

2. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

1.04 QUALITY ASSURANCE

A. Mock-Ups:
   1. Welding demonstration:
      a. Demonstrate ability to weld acceptable joints in polyvinyl chloride waterstops before installing waterstop in forms, if requested by the Engineer.

B. Field joints:
   1. Polyvinyl chloride waterstops field joints: Shall be free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets and other defects which would reduce the potential resistance of the material to water pressure at any point. Replace defective joints. Remove faulty material from the site and disposed of by the Contractor at its own expense.

C. Inspections:
   1. Quality of welded joints will be subject to acceptance of the Engineer.
   2. Polyvinyl chloride waterstop: The following defects that represent a partial list that will be grounds for rejection:
      a. Offsets at joints greater than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
      b. Exterior crack at joint, due to incomplete bond, which is deeper than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
      c. Any combination of offset or crack which will result in a net reduction in the cross section of the waterstop in excess of 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
      d. Misalignment of the joint, which will result in misalignment of the waterstop in excess of 1/2 inch in 10 feet.
      e. Porosity in the welded joint as evidenced by visual inspection.
      f. Bubbles or inadequate bonding.

PART 2 PRODUCTS

2.01 MATERIALS

A. Polyvinyl chloride waterstops: Manufactured from prime virgin polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements of this Specification. No scrap or reclaimed material shall be used.

2.02 MANUFACTURED UNITS

A. Waterstops:
   1. Polyvinyl chloride waterstops:
      a. Manufacturers: One of the following or equal:
         1) Vinylex Corporation, Kwik-Tie.
         2) Greenstreak Plastic Products Company, Inc.

b. Type: ribbed waterstop:
   1) Construction Joints: 6 inch wide ribbed type.
   2) Expansion Joint for Wall Penetrations for Concrete Encased Electrical Duct Banks: 6 inch ribbed type with hollow center bulb.
   3) Expansion Joints: 9 inch wide ribbed type with hollow center bulb.

c. Provide polyvinyl chloride waterstops complying with following requirements:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D 792	Not less than 1.3.
Hardness	ASTM D 2240	70 to 90 Type A Shore durometer.
Tensile Strength	ASTM D 638	Not less than 2,000 pounds per square inch.
Ultimate Elongation	ASTM D 638	Not less than 350 percent
Alkali Extraction	CRD-C-572	7 day weight change between minus 0.1 percent and plus 0.25 percent.
Low Temperature Brittle Point	ASTM D 746	Not more than minus 35 degrees Fahrenheit.
Water Absorption	ASTM D 570	Not more than 0.15 percent after 24 hours.
Accelerated Extraction Tensile	CRD-C-572	Not less than 2,000 pounds per square inch.
Stiffness in Flexure	ASTM D 747	Not less than 725 pounds per square inch.
Tear Resistance	ASTM D 624	Not less than 300 pounds per inch.
Weight Requirements		
6 inch Waterstops	–	Weigh not less than 130 pounds per 100 linear feet.
9 inch Waterstops	–	Weigh not less than 220 pounds per 100 linear feet.
Thickness	–	3/8 inch
Center Bulb		
6 inch Waterstops	–	7/8 inch or 1 inch nominal outside diameter.
9 inch Waterstops	–	1 inch nominal outside diameter. For expansion joints 1 inch and narrower and 2 inches for expansion joints wider than 1 inch.
Allowable Tolerances		
Width	–	Plus or minus 3/16 inch.
Thickness	–	Plus or minus 1/32 inch.

d. Dumbbell type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.

B. Preformed expansion joint materials:
   1. Preformed synthetic sponge rubber expansion joint material:
      a. Manufacturers: One of the following or equal:
         1) Tamms Industries, Inc., Cementone.
         2) Burke Concrete Accessories Inc., Neoprene Sponge Rubber Expansion Joint.
   2. Preformed bituminous fiber expansion joint material:
      a. Manufacturers: One of the following or equal:
         1) Tamms Industries, Inc., Hornboard/fiber.
         2) Burke Concrete Accessories Inc., Fiber Expansion Joint.
   3. Use specific type in applications as indicated on the Drawings.
   4. No scrap or recycled material shall be used.

PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops - General:
   1. Waterstops shall be stored so as to permit free circulation of air around the waterstop material and to prevent direct exposure to sunlight.
   2. Install waterstops in concrete joints where indicated on the Drawings.
   3. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
   4. In waterbearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
   5. Provide waterstops that are continuous.
   6. Set waterstops accurately to position and line as indicated on the Drawings.
   7. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.
   8. Position the waterstop so that symmetrical halves of the waterstop are equally divided between the concrete pours. The center axis of the waterstop shall be coincident with the centerline of the joint.
   9. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
   10. Use wires at not more than 24 inches on centers near outer edge of the waterstop to tie waterstops into position.
   11. Special clips may be used in lieu of wires, at Contractor's option.
   12. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
   13. When any waterstop is installed in the concrete on one side of a joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of sunlight during the entire exposure and until the exposed portion is embedded in concrete.
   14. When placing concrete at waterstops in slabs, lift the edge of the waterstop while placing concrete below the waterstop. Manually force the waterstop against and into the concrete. Then cover the waterstop with fresh concrete.

B. Polyvinyl chloride waterstops:
   1. Install waterstops so that joints are watertight.
   2. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:
      a. The material shall not be damaged by heat sealing.
      b. Make joints by overlapping then simultaneously cut the ends of the sections to be spliced so they will form a smooth even joint. Heat the cut ends with the splicing tool until the plastic melts. Press the 2 ends together until the plastic cools.
      c. The continuity of the waterstop ribs and tubular center axis shall be maintained.
      d. The splices shall have a tensile strength of not less than 60 percent of the unspliced materials tensile strength.
   3. Butt joints of the ends of 2 identical waterstop sections may be made while the material is in the forms.
   4. All joints with waterstops involving more than 2 ends to be joined together, and all joints that involve an angle cut, alignment change, or the joining of 2 dissimilar waterstop sections shall be prefabricated by the Contractor or the manufacturer prior to placement in the forms, providing not less than 24 inch long strips of waterstop material beyond the joint. Upon being inspected and accepted, install such prefabricated waterstop joint assemblies in the forms and the ends of the 24-inch strips shall be butt welded to the straight run portions of waterstop in place in the forms.
   5. Vertical crosses and tees shall be factory prefabricated by the manufacturer. Horizontal crosses or tees may be field or factory welded.
   6. Split type waterstop will not be permitted except where specifically indicated on the Drawings.

C. Joints:
   1. Construct contraction, construction, and expansion joints as indicated on the Drawings.
   2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

END OF SECTION

SECTION 03154

HYDROPHILIC RUBBER WATERSTOP

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Hydrophilic rubber waterstop.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
   2. D 570 - Standard Test Method for Water Absorption of Plastics.
   3. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   4. D 2240 - Standard Test Method for Rubber Property-Durometer Hardness.

1.03 SUBMITTALS

A. General:
   1. Submit the following items for each type, style and size of hydrophilic waterstop to be installed.
   2. Product data:
      a. Manufacturer’s product data sheets.
         1) Include complete physical dimensions, expansion characteristics, and laboratory test reports indicating that average material properties conform to the requirements specified.
         2) Provide data sheets for all materials to be included in the waterstop system.
   3. Samples:
      a. Minimum 6-inch long samples of each type of waterstop to be used if requested by the Engineer.
   4. Manufacturer's installation instructions:
      a. Installation instructions and recommended installation details for the complete waterstop system, and for each component used in that system.

PART 2 PRODUCTS

2.01 HYDROPHILIC RUBBER WATERSTOP

A. General:
   1. System composed of flexible hydrophilic urethane polymer with preformed strips, adhesives, paste, fasteners, and other accessories required for a complete and watertight installation.
      a. To ensure compatibility of materials, a single manufacturer shall provide all products and accessories for the hydrophilic waterstop system.
      b. Products incorporating bentonite are not acceptable under this Section.

c. Provide waterstop and accessories resistant to degradation under cyclic wetting and drying and to chemicals typically found in water treatment structures.

B. Hydrophilic strip waterstop:
   1. Pre-formed strips of flexible hydrophilic rubber designed to undergo controlled expansion when exposed to moisture.
   2. Strip waterstops reinforced with embedded stainless steel wire mesh designed to direct expansion in the thickness direction of the strip, and to limit expansion in the longitudinal and width directions.
   3. Provide normal or low-expansion pressure In accordance with the following performance requirements:

Property	Test Method	Required Result
Hardness Hs	ASTM D 2240	Not less than 30 + 6 Shore A Durometer Type A.*
Tensile Strength	ASTM D 412	Not less than 142 pounds per square inch*
Elongation	ASTM D 412	Not less than 500 percent*
Specific Gravity	ASTM D 792	1.18 + 0.15
Expansion Coefficient by Volume	(manufacturer)	Not less than 1.9
Water Absorption	ASTM D 570	Not more than 0.15 percent after 24 hours
* Based on pressed sheet of compound.		

   4. Manufacturers: One of the following or equal:
      a. Hydrophilic strip: Adeka Ultra Seal USA: MC-2010MN.
      b. Low expansion hydrophilic strip: Adeka Ultra Seal USA: KBA-1510FP.

C. Hydrophilic strip waterstop.
   1. Pre-formed strips of flexible hydrophilic rubber designed to undergo controlled expansion when exposed to moisture.
      a. Strips manufactured to limit expansion in directions parallel to the plane of the joint, and to direct expansion against confining material perpendicular to that plane.
   2. Provide normal or low-expansion pressure as scheduled and as indicated on the Drawings.
   3. Manufacturers. One of the following, or equal.
      a. Hydrophilic strip.
         1) Adeka Ultra Seal USA: MC-2010MN.
         2) Greenstreak: Hydrotite CJ1020-2K.
      b. Low expansion hydrophilic strip.
         1) Adeka Ultra Seal USA: KBA-1510FP.
         2) Greenstreak: Hydrotite CJ0725-3K.

D. Hydrophilic paste waterstop.
   1. Single-component gun grade paste of hydrophilic rubber designed to undergo controlled expansion when exposed to moisture after initial curing.

2. Manufacturers: One of the following, or equal.
    a. Adeka Ultra Seal USA: P-201.
    b. Greenstreak: Leakmaster LV-1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions and recommended details.

B. Prepare concrete joint surfaces:
    1. Use wire brushing or scraping to expose an uncontaminated, solid surface.
    2. Clean prepared surface with high-pressure air or water to remove residue and debris.
    3. Confirm that prepared surfaces conform to manufacturer’s recommendations for surface profile and moisture conditions before installing materials.

C. Provide manufacturer’s recommended lap, splice, and corner details for hydrophilic waterstops.
    1. Use hydrophilic paste at all corner joints and overlap splices of hydrophilic strips.

D. Hydrophilic strip waterstop.
    1. Install primers and adhesives when recommended by the manufacturer before setting hydrophilic strips.
    2. Keep hydrophilic strip taut during the fastening process.
    3. Secure hydrophilic strip in place with concrete nails, screws, or adhesive.
    4. Provide installation with no gap between the hydrophilic strip and the concrete to which it is attached. At rough or irregular surfaces, set hydrophilic strip waterstop strip in a bead of hydrophilic paste.
        a. Fill all voids and rough areas under the hydrophilic strip with hydrophilic paste.
        b. Allow hydrophilic paste to cure in accordance with manufacturer’s recommendations before encapsulating paste in fresh concrete.

3.02 SCHEDULE

A. Concrete construction joints:
    1. Joint where hydrophilic strip waterstop is placed under all of the following conditions:
        a. Slab or wall thickness is greater than 10 inches, and
        b. Waterstop is placed between 2 rows of steel reinforcement.
        c. Concrete cover from waterstop to nearest concrete face is at least 4 inches.
    2. Hydrophilic strip waterstop set in bed of hydrophilic paste waterstop. Screw strip to concrete substrate.
    3. Joint where hydrophilic waterstop is placed under one of the following conditions:
        a. Waterstop is placed on 1 side of a single row of steel reinforcement, or
        b. Concrete cover from waterstop to nearest concrete face is less than 4 inches.

4. Low expansion hydrophilic strip waterstop set in bed of hydrophilic paste waterstop. Screw strip to concrete substrate.

B. Pipe penetrations through concrete:
   1. Pipe diameter less than 4 inches: Not allowed.
   2. Pipe diameter of 4 to 24 inches: Continuous bead of hydrophilic paste waterstop, minimum 1/4 inch high by 1/2 inch wide, encircling pipe.
   3. Pipe diameter greater than 24 inches: Continuous hydrophilic strip waterstop around perimeter of pipe, with hydrophilic paste seal at lapped ends of strip.

END OF SECTION

SECTION 03200

CONCRETE REINFORCING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Bar supports.
   2. Reinforcing bars.
   3. Tie wires.
   4. Welded wire fabric reinforcement.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 315 - Details and Detailing of Concrete Reinforcement.
   2. 318 - Building Code Requirements for Structural Concrete and Commentary.
   3. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.

B. American Welding Society (AWS):
   1. D1.4 - Structural Welding Code - Reinforcing Steel.

C. ASTM International (ASTM):
   1. A 185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   2. A 615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   3. A 706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

1.03 DEFINITIONS

A. Give away bars: Bars that are not required by Contract Documents, but are installed by the Contractor to support the required reinforcing bars.

1.04 SYSTEM DESCRIPTION

A. The Drawings contain general notes concerning amount of reinforcement and placing, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete.

1.05 SUBMITTALS

A. Shop drawings:
   1. Changes to reinforcing steel contract drawing requirements:
      a. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on the Drawings for reinforcing steel.
      b. Such changes will not be acceptable unless the Engineer has accepted such changes in writing.
   2. Reinforcement shop drawings:
      a. Review of reinforcement shop drawings by the Engineer will be limited to general compliance with the Contract Documents.
      b. Submit reinforcement shop drawings in a complete package for each specific structure. Partial submittals will be rejected.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver bars bundled and tagged with identifying tags.

B. Acceptance at site:
   1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks accompanied by manufacturer's guarantee of grade.

1.07 SEQUENCING AND SCHEDULING

A. Bar supports: Do not place concrete until samples and product data for bar supports have been accepted by the Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

A. Bar supports:
   1. Wire bar supports located between reinforcing bars and face of concrete:
      a. Hot-dip galvanized steel bar support chairs with plastic tips.
         1) Support reinforcing for concrete placed on ground using bar support chairs with hot dip galvanized plates for resting on ground welded to the chairs.
   2. Wire bar supports located between mats of reinforcing bar:
      a. Steel bar supports.

B. Reinforcing bars:
   1. Reinforcing bars to be embedded in concrete:
      a. ASTM A 615 Grade 60 deformed bars.
         1) Actual yield strength based on mill tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
         2) Ratio of the actual ultimate tensile strength to the actual tensile yield strength of the reinforcement shall not be less than 1.25.

2. Reinforcing bars that are required to be welded:
    a. Low alloy ASTM A 706 Grade 60 deformed bars.
3. Reinforcing bars that are required to resist earthquake-induced flexural and axial forces in concrete frame members and in concrete shear wall boundary members:
    a. Low alloy ASTM A 706 Grade 60 deformed bars.

C. Tie wires: Annealed steel.

D. Welded wire fabric reinforcement:
1. In accordance with ASTM A 185.
2. Fabric may be used in place of reinforcing bars if accepted by the Engineer.
3. Provide welded wire fabric in flat sheet form.
4. Provide welded wire fabric having cross-sectional area per linear foot of not less than cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.
5. Fabric on bridge handrails shall be hot-dip galvanized.

2.02 FABRICATION

A. Shop assembly:
1. Cut and bend bars in accordance with provisions of ACI 315, ACI 318, and ACI 350.
2. Bend bars cold.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
1. Reinforcing bars and welded wire fabric reinforcement: Verify that reinforcement is new stock free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings which adversely affect bonding capacity when placed in the work.

3.02 PREPARATION

A. Surface preparation:
1. Reinforcing bars: Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean any bars having rust scale, loose mill scale, or thick rust coat.
2. Cleaning of reinforcement materials: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placement.

3.03 INSTALLATION

A. Reinforcing bars:
1. No field bending of bars will be allowed.
2. Hoop bars shall be rolled to the radius of the structure.

3. Welding:
    a. Weld reinforcing bars where indicated on the Drawings or acceptable to the Engineer.
    b. Perform welding in accordance with AWS D1.4 and welding procedures accepted by the Engineer.
        1) Conform to requirements for minimum preheat and interpass temperatures.
    c. Submit welding procedures.
    d. Do not tack weld reinforcing bars.

B. Placing reinforcing bars:
1. Accurately place bars to meet tolerances of ACI 318 and adequately secure them in position.
2. Lap bars at splices as indicated on the Drawings or specified.
    a. Unless specifically otherwise indicated on the Drawings, install bars at lap splices in contact with each other and fasten together with tie wire.
    b. Where reinforcing bars are to be lap spliced at concrete joints, ensure that bars project from first concrete placement a length equal to or greater than the minimum lap splice length indicated on the Drawings.
    c. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318 and ACI 350.
3. Bar supports:
    a. Provide a sufficient number to prevent sagging, to prevent shirting, and to support loads during construction; but in no case less than quantities and at locations as indicated in ACI 315.
    b. Do not use brick, broken concrete masonry units, spalls, rocks, wood or similar materials for supporting reinforcing steel.
    c. Do not use give away bars that have less cover than required by the Contract Documents. Do not adjust location of reinforcement required by the Contract Documents to provide cover to the give away bars.
4. If not indicated on the Drawings, provide protective concrete cover in accordance with ACI 318 and ACI 350.

C. Tying of bar reinforcement:
1. Fasten bars securely in place with wire ties.
2. Tie bars sufficiently often to prevent shifting.
3. Provide at least 3 ties in each bar length.
    a. Do not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity.
4. Tie slab bars at every intersection around periphery of slab.
5. Tie wall bars and slab bar intersections other than around periphery at not less than every fourth intersection, but at not greater than following maximum spacings:

Bar Size	Slab Bar Spacing Inches	Wall Bar Spacing Inches
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

6. After tying wire ties, bend ends of wire ties in towards the center of the concrete section.
    a. The cover for wire ties shall be the same as the cover requirements for reinforcing bars.

D. Welded wire fabric reinforcement:
    1. Install necessary wiring, spacing chairs, or supports to keep welded wire fabric in place while concrete is being placed.
    2. Bend fabric as indicated on the Drawings or required to fit work.
    3. Unroll or otherwise straighten fabric to make flat sheet before placing in the Work.
    4. Lap splice welded wire fabric as indicated on the Drawings.
    5. If lap splice length is not indicated on the Drawings, splice fabric in accordance with ACI 318 and ACI 350.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Cast-in-place concrete.

B. Related Sections:
1. Section 03071 - Epoxies.
2. Section 03150 - Concrete Accessories.
3. Section 03366 - Tooled Concrete Finishes.
4. Section 07900 - Joint Sealers.

1.02 REFERENCES

A. American Concrete Institute (ACI):
1. 318 - Building Code Requirements for Structural Concrete and Commentary.
2. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
3. Manual of Concrete Practice.
4. Recommended Practices.

B. ASTM International (ASTM):
1. C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
2. C 33 - Standard Specification for Concrete Aggregates.
3. C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
4. C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
5. C 42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
6. C 88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
7. C 94 - Standard Specification for Ready-Mixed Concrete.
8. C 114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
9. C 117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
10. C 123 - Standard Test Method for Lightweight Particles in Aggregate.
11. C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
12. C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
13. C 142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
14. C 143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
15. C 150 - Standard Specification for Portland Cement.

16. C 156 - Standard Test Method for Water Retention by Concrete Curing Materials.
17. C 157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
18. C 171 - Standard Specifications for Sheet Materials for Curing Concrete.
19. C 172 - Standard Practice for Sampling Freshly Mixed Concrete.
20. C 173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
21. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
22. C 289 - Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
23. C 295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
24. C 309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
25. C 311 – Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete.
26. C 469 - Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
27. C 494 - Standard Specification for Chemical Admixtures for Concrete.
28. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
29. D 75 - Standard Practice for Sampling Aggregates.
30. D 2103 - Standard Specification for Polyethylene Film and Sheeting.

1.03 DEFINITIONS

A. Alkali: Is defined as the sum of sodium oxide and potassium oxide calculated as sodium oxide.

B. Cementitious materials: Defined as portland cement and pozzolan admixture.

C. Hairline crack: Crack with a crack width of less than 12 thousandths of an inch.

1.04 SYSTEM DESCRIPTION

A. Performance requirements:
   1. General:
      a. Except as otherwise specified, provide concrete composed of portland cement, fly ash, fine aggregate, coarse aggregate, and water so proportioned and mixed as to produce plastic, workable mixture in accordance with requirements as specified in this Section and suitable to specific conditions of placement.
      b. Proportion materials in a manner such that will secure lowest water-cement ratio which is consistent with good workability, plastic, cohesive mixture, and 1 which is within specified slump range.
      c. Proportion fine and coarse aggregates in manner such as not to produce harshness in placing or honeycombing in structures.

2. It is the intent of this Section to secure for every part of the Work concrete and grout of homogeneous structure, which when hardened will have required strength, watertightness, and durability:
    a. It is recognized that some surface hairline cracks and crazing will develop in the concrete surfaces.
    b. Construction and expansion joints have been specified and positioned in structures as indicated on the Drawings, and curing methods specified, for purpose of reducing number and size of cracks, due to normal expansion and contraction expected from specified concrete mixes. Class A and Class B Concrete: Watertight: Repair cracks which develop in walls or slabs and repair cracks which show any signs of leakage until all leakage is stopped.
    c. Pressure inject visible cracks, other than hairline cracks and crazing, in following areas with epoxy as specified in Section 03931:
        1) Floors and walls of water bearing structures.
        2) Walls and overhead slabs of passageways or occupied spaces, outsides of which are exposed to weather or may be washed down and are not specified to receive separate waterproof membrane.
        3) Other items not specified to receive separate waterproof membrane: Slabs over water channels, wet wells, reservoirs, and other similar surfaces.
    d. Walls or slabs, as specified above, that leak or sweat because of porosity or cracks too small for successful pressure grouting: Seal on water or weather side by coatings of surface sealant system, as specified in this Section.
    e. Grouting and sealing: Continue as specified above until structure is watertight and remains watertight for not less than 1 year after final acceptance or date of final repair, whichever occurs later in time.
3. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI 318, ACI 350, Manuals, and Recommended Practices.

1.05 SUBMITTALS

A. Product data: Submit data completely describing products.

B. Information on heating equipment to be used for cold weather concreting: Submit information on type of equipment to be used for heating materials and/or new concrete in process of curing during excessively cold weather.

C. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Submit corrective measures proposed for use prior to placing concrete.

D. Copies of tests of concrete aggregates: Submit certified copies in triplicate of commercial laboratory tests not more than 180 days old of all samples of concrete aggregates:
    1. Fine aggregate:
        a. Clay lumps.
        b. Reactivity.
        c. Shale and chert.
        d. Soundness.

e. Color.
f. Decantation.

2. Coarse aggregate:
   a. Clay lumps and friable particles.
   b. Reactivity.
   c. Shale and chert.
   d. Soundness.
   e. Abrasion loss.
   f. Coal and lignite.
   g. Materials finer than 200 sieve.

E. Sieve analysis: Submit sieve analyses of fine and coarse aggregates being used in triplicate at least every 3 weeks and at any time there is significant change in grading of materials.

F. Concrete mixes: Submit full details, including mix design calculations for concrete mixes proposed for use for each class of concrete:
   1. Include information on correction of batching for varying moisture contents of fine aggregate.
   2. Submit source quality test records with mix design submittal:
      a. Include calculations for f'_{cr} based on source quality test records.

G. Trial batch test data:
   1. Submit data for each test cylinder.
   2. Submit data that identifies mix and slump for each test cylinder.

H. Sequence of concrete placing: Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements.

I. Curing compound other than specified compound: Submit complete data on proposed compound.

J. If either fine or coarse aggregate is batched from more than 1 bin: Submit analyses for each bin, and composite analysis made up from these, using proportions of materials to be used in mix.

K. Cement mill tests: Include alkali content, representative of each shipment of cement for verification of compliance with specified requirements.

L. Pozzolan Certificate of Compliance: Identify source of pozzolan and certify compliance with requirements of ASTM C 618.

M. Information on mixing equipment.

N. Results of concrete specimen 7, 14, and 28 day shrinkage tests. If available, test results conducted in prior 12 months using the same aggregate supply source may be submitted in lieu of new tests. If shrinkage exceeds 0.045 percent at 28 days, consider alternative mix designs that include Eclipse shrinkage reducing admixture.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
   2. Deliver and store packaged materials in original containers until ready for use.
   3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.

B. Acceptance at Site: Reject material containers or materials showing evidence of water or other damage.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Hot weather concreting:
      a. When ambient air temperature Is above 90 degrees Fahrenheit: Prior to placing concrete, cool forms and reinforcing steel to by water cooling to below 90 degrees Fahrenheit.
      b. Temperature of concrete mix at time of placement: Keep temperature below 90 degrees Fahrenheit by methods which do not impair quality of concrete.
   2. Cold weather concreting:
      a. Concrete placed below ambient air temperature of 45 degrees Fahrenheit and falling or below 40 degrees Fahrenheit: Make provision for heating water.
      b. If materials have been exposed to freezing temperatures to degree that any material is below 35 degrees Fahrenheit: Heat such materials.
      c. Heating water, cement, or aggregate materials:
         1) Do not heat in excess of 160 degrees Fahrenheit.
      d. Protection of concrete in forms:
         1) Protect by means of covering with tarpaulins, or other acceptable covering acceptable to Engineer.
         2) Provide means for circulating warm moist air around forms in manner to maintain temperature of 50 degrees Fahrenheit for at least 5 days.
   3. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Take corrective measures to minimize rapid water loss from concrete:
      a. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature around concrete.

1.08 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in such manner as to complete any single placing operation to construction, contraction, or expansion joint.

PART 2 PRODUCTS

2.01 MATERIALS

A. Admixtures:
   1. General:
      a. Do not use admixtures of any type, except as specified, unless written authorization has been obtained from the Engineer.
      b. Compatible with concrete and other admixtures.
      c. Do not use admixtures containing chlorides calculated as chloride ion in excess of 0.5 percent by weight of cement.
      d. Use in accordance with manufacturer's recommendations and add each admixture to concrete mix separately.
   2. Air entraining admixture:
      a. Provide all concrete with 5 percent, plus or minus 1 percent, entrained air of evenly dispersed air bubbles at time of placement.
      b. Conform to ASTM C 260.
   3. Pozzolan admixture:
      a. Fly ash in accordance with requirements of ASTM C 618, Class F, may be used as admixture in concrete made with Type II portland cement.
      b. Maximum of 15 percent by weight of pozzolan admixture to total weight of cementitious materials. The total weight of cementitious materials shall not be less than minimum cementitious materials listed in Table A.
      c. Do not use pozzolan admixture as an admixture in concrete made with portland-pozzolan cement.
      d. Loss on ignition for pozzolan admixture: Not exceed 4 percent.
   4. Water reducing admixtures:
      a. May be used at the Contractor's option.
      b. Conform to ASTM C 494, Type A or Type D.
      c. Not to contain air-entraining agents within chemicals.
      d. Liquid form before adding to the concrete mix.
      e. No decrease in cement is permitted as result of use of water reducing admixture.
   5. Shrinkage reducing admixtures:
      a. May be utilized to obtain required shrinkage values noted herein.
         1) Eclipse Plus by W.R. Grace & Co. (air-entrained concrete)
         2) Eclipse Floor by W.R. Grace & Co. (non-air-entrained concrete)

B. Aggregate:
   1. General:
      a. Provide concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of allowable amounts specified.
      b. Grade aggregate in accordance with ASTM C 136 and D 75.
      c. Provide unit weight of fine and coarse aggregate that produces in place concrete with weight of not less than 140 pounds per cubic foot.
      d. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
   2. Fine aggregate:
      a. Provide fine aggregate for concrete or mortar consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.

b. Do not provide aggregate having deleterious substances in excess of following percentages by weight of contaminating substances. In no case shall total exceed percent listed.

Item	Test Method	Percent
Removed by decantation (dirt, silt, etc.)	ASTM C 117	3
Shale or Chert	ASTM C 123 ASTM C 295*	1 1
Clay Lumps	ASTM C 142	1

* Test Method C 123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C 295 is used to identify which of the lightweight particles are shale or chert. If the results of Test Method C 123 are less than 1 percent, Test Method C 295 is not required.

c. Except as otherwise specified, grade fine aggregate from coarse to fine in accordance with requirements of ASTM C 33.

3. Coarse aggregate:
   a. General: Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances.
   b. Weight: Not exceeding 15 percent, for thin or elongated pieces having length greater than 5 times average thickness.
   c. Deleterious substances: Not in excess of following percentages by weight, and in no case having total of all deleterious substances exceeding 2 percent.

Item	Test Method	Percent
Shale or chert	ASTM C 123 ASTM C 295**	1.25 1
Coal and lignite	ASTM C 123	1/4
Clay lumps and friable particles	ASTM C 142	1/4
Materials finer than Number 200 sieve	ASTM C 117	1/2*

* Except when material finer than Number 200 sieve consists of crusher dust, maximum amount shall be 1 percent.

** Test Method C 123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C 295 is used to identify which of the lightweight particles are shale, chert, coal or lignite. If the results of Test Method C 123 are less than 1.25 percent (the minimum combined percentage of shale, chert, coal and lignite), Test Method C 295 is not required.

   d. Grading:
      1) Aggregate for Class A, B, C, and D concrete: As specified in ASTM C 33, Size Number 57, except as otherwise specified or authorized in writing by the Engineer.
      2) Aggregate for Class CE concrete for encasement of electrical conduits:
         a) Graded as specified in ASTM C 33, Size Number 8.

C. Conduit encasement coloring agent:
   1. Color: Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
   2. Manufacturers: One of the following or equal:
      a. Davis Company, #100 Utility Red.
      b. I. Reiss Company, Inc., equivalent product.
   3. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

D. Evaporation retardant:
   1. Manufacturers: One of the following or equal:
      a. Master Builders Technologies, Cleveland, Ohio, Confilm.
      b. Euclid Chemical Company, Cleveland, Ohio, Eucobar.

E. Keyway material: Steel, plastic, or lumber.

F. Portland cement:
   1. General: Conform to specifications and tests for ASTM C 150, Types II or III, low alkali, except as specified otherwise.
   2. Low alkali portland: Have total alkali containing not more than 0.60 percent.
   3. Exposed concrete in any individual structure: Use only one brand of portland cement.
   4. Cement for finishes: Provide cement from same source and of same type as concrete to be finished.

G. Plastic membrane curing: Use polyethylene film in accordance with ASTM C 171:
   1. Color: White.
   2. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D 2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
   3. Loss of Moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C 156.

H. Sprayed membrane curing compound: Clear type with fugitive dye conforming to ASTM C 309, Type 1D.

I. Water:
   1. Water for concrete, washing aggregate, and curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
   2. Chlorides and sulfate ions:
      a. Water for conventional reinforced concrete: Use water not containing more than 1,000 milligrams per liter of chlorides calculated as chloride ion, nor more than 1,000 milligrams per liter of sulfates calculated as sulfate ion.
      b. Water for prestressed or post-tensioned concrete: Use water not containing more than 650 milligrams per liter of chlorides calculated as chloride ion, nor more than 800 milligrams per liter of sulfates calculated as sulfate ion.

2.02 EQUIPMENT

A. Mixing concrete:
   1. Mixers may be of stationary plant, paver, or truck mixer type.
   2. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material.
   3. Mixing equipment:
      a. Capable of combining aggregates, cementitious materials, and water within specified time into thoroughly mixed and uniform mass and discharging mixture without segregation.
      b. Maintain concrete mixing plant and equipment in good working order and operated at loads, speeds, and timing recommended by manufacturer or as specified.
      c. Proportion cementitious materials and aggregate by weight.

B. Machine mixing:
   1. Batch plant shall be capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.
   2. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
   3. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
   4. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
   5. Retempering of concrete will not be permitted.
   6. Discharge entire batch before recharging.
   7. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
   8. Mixers:
      a. Perform mixing in batch mixers of acceptable type.
      b. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
      c. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
         1) Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.

C. Transit-mixed concrete:
   1. Mix and deliver in accordance with ASTM C 94.
   2. Total elapsed time between addition of water at batch plant and discharging completed mix: Not to exceed 90 minutes. Elapsed time at project site shall not exceed 30 minutes.
   3. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
   4. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish such device that is capable of counting number of revolutions of drum.

5. Continuously revolve drum after it is once started until it has completely discharged its batch:
    a. Do not admit water until drum has started revolving.
    b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. The Contractor will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: In case of other types of mixers, mixing shall be as follows:
1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.03 MIXES

A. Measurements of materials:
1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
5. Weighing cementitious materials:
    a. Weigh cementitious materials separately.
    b. Cement in unbroken standard packages (sacks): Need not be weighed.
    c. Bulk cementitious materials and fractional packages: Weigh such cementitious materials.
6. Mixing water: Measured by volume or by weight.

B. Concrete proportions and consistency:
1. Concrete consistency and composition:
    a. Provide concrete that can be worked readily into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on surface.
    b. Prevent unnecessary or haphazard changes in consistency of concrete.
2. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete classes.
3. Aggregate:
    a. Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operation.
4. Concrete mix water to cementitious materials ratio, minimum cementitious materials content, and slump range: Conform to values specified in Table A in this Section.
5. Concrete batch weights: Control and adjust to secure maximum yield. At all times, maintain proportions of concrete mix within specified limits.

6. Mix modification: If required, by the Engineer, modify mixture within limits set forth in this Section.

C. Concrete mixes:
   1. Proportioning of concrete mix: Proportion mixes based on required average on compressive strength f'_{cr}.
   2. Mixes:
      a. Adjusting of water: After acceptance, do not change mixes without acceptance by Engineer, except that at all times adjust batching of water to compensate for free moisture content of fine aggregate.
      b. Total water content of each concrete class: Not exceed those specified in Table A in this Section.
      c. Checking moisture content of fine aggregate: Furnish satisfactory means at batching plant for checking moisture content of fine aggregate.
   3. Change in mixes: Submit new mix design and undertake new trial batch and test program as specified in this Section.

D. Hand mixed concrete:
   1. Hand mix concrete only when acceptable to the Engineer.
   2. Prepare hand mixed concrete on watertight, level platform in batches not to exceed 1/3 cubic yard each.
   3. Aggregate:
      a. First, spread required amount of coarse aggregate on platform in an even and uniform layer. Then over coarse aggregate, spread proper proportion of fine aggregate.
      b. Depth of combined coarse and fine aggregate layers: Not be greater than 1 foot.
   4. Cementitious materials:
      a. First, evenly spread required quantity of cementitious materials over fine aggregate.
      b. Then turn entire batch with shovels at least 2 times before adding water.
   5. Water:
      a. Then uniformly sprinkle or spray proper amount of water over batched materials.
      b. Then turn with shovels not less than 3 times before concrete is removed from platform.

E. Classes of concrete:
   1. Provide concrete consisting of 5 classes, referred herein as Classes A, B, C, D, and CE as specified in this Section. Use where specified or indicated on the Drawings.
   2. Weight of concrete classes: Provide classes of concrete having minimum weight of 140 pounds per cubic foot.
   3. Class B concrete: Class B concrete may be substituted for Class A concrete, when high-early strength concrete is needed in areas specifically accepted by the Engineer and that do not require sulfate resistant concrete.
   4. Class C concrete: Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
   5. Class CE concrete: Use for electrical conduit encasement with red coloring agent.
   6. Class D concrete: Use Class D for precast concrete items.

7. All other concrete, unless specified or otherwise indicated on the Drawings: Use Class A concrete.

TABLE A CONCRETE WITH AIR ENTRAINMENT				
Class	**Specified Compressive Strength f'_c at 28 Days (Pounds per Square Inch)**	**Maximum Water-to-Cementitious Materials Ratio**	**Minimum Cementitious Materials per Cubic Yard of Concrete by Weight (Pounds)**	**Slump Range (Inches)**
A	4,000	0.45	564	2 to 4
B (Type III cement)	4,000	0.45	564	2 to 4
C	2,500	0.55	470	3 to 6
CE	2,500	0.62	564	3 to 6
D	4,500	0.40	611	2 to 4

8. Pumped concrete: Provide pumped concrete that complies with all requirements of this Section.
9. Do not place concrete with slump outside limits indicated in Table A.
10. Classes:
    a. Classes A, C, and D concrete: Make with Type II low alkali portland cement.
    b. Class B concrete: Make with Type III low alkali portland cement.
    c. Admixtures: Provide admixtures as specified in this Section.

F. Air entraining admixture:
1. Add agent to batch in portion of mixing water.
2. Batch solution by means of mechanical batcher capable of accurate measurement.

2.04 SOURCE QUALITY CONTROL

A. Tests:
1. Trial batches:
    a. After concrete mix designs have been accepted by Engineer, have trial batches of the accepted Class A, Class B, and Class D concrete mix designs prepared by testing laboratory acceptable to the Engineer.
    b. Prepare trial batches using specified cementitious materials and aggregates proposed to be used for the Work.
    c. Prepare trial batches with sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient test cylinders.
    d. Test cylinders: Provide cylinders having 6-inch diameter by 12-inch length and that are prepared in accordance with ASTM C 31 for tests specified in this Section.
    e. Determine slump in accordance with ASTM C 143.
    f. Test cylinders from trial batch:
        1) Test 8 cylinders for compressive strength in accordance with ASTM C 39:
            a) Test 4 cylinders at 7 days and 4 at 28 days.

b) Establish ratio between 7 day and 28 day strength for mix. Seven-day strength may be taken as satisfactory indication of 28-day strength provided effects on concrete of temperature and humidity between 7 day and 28 day are taken into account.

2) Average Compressive Strength of 4 Test Cylinders Tested At 28 Days: Equal to or greater than required average compressive strength f'_{cr} on which concrete mix design is based.

g. If trial batch tests do not meet specified requirements for slump, strength, workability, consistency, modulus of elasticity, drying shrinkage, and finishing, change concrete mix design proportions and, if necessary, source of aggregate. Make additional trial batches and tests until an acceptable trial batch is produced that meets requirements of this Section.

h. Perform test batches and tests required to establish trial batches and acceptability of materials without change in Contract Price.

i. Do not place concrete until the concrete mix design and trial batch have been accepted by Engineer.

2. Required average compressive strength:

a. Determine required average compressive strength (f'_{cr}) for selection of concrete proportions for mix design, for each class of concrete, using calculated standard deviation and its corresponding specified compressive strength f'_c, in accordance with ACI 318 and ACI 350.

b. When test records of at least 30 consecutive tests that span period of not less than 45 calendar days are available, establish standard deviation as described in ACI 318 and ACI 350 and as modified as follows herein.

c. Provide test records from which to calculate standard deviation that represent materials, quality control procedures, and conditions similar to materials, quality control procedures, and conditions expected to apply in preparation of concrete for the Work.

d. Provide changes in materials and proportions within test records that are more restricted than those for the Work.

e. Specified Compressive Strength (f'_c) of Concrete Used in Test Records: Within 1,000 pounds per square inch of that specified for the Work.

f. When lacking adequate test records for calculation of standard deviation meeting requirements, determine required average compressive strength f'_{cr} from following Table B.

TABLE B

Specified Compressive Strength f'_c (pounds per square inch)	**Required Average Compressive Strength f'_{cr} (pounds per square inch)**
Less than 3,000	$f'_c + 1,000$
3,000 to 5,000	$f'_c + 1,200$
Over 5,000	$1.10\ f'_c + 700$

3. Pozzolan admixture:

a. Sampling and Testing:

1) Sample and test pozzolan admixture in accordance with ASTM C 311.

4. Aggregate:

a. Testing of concrete aggregate is at Contractor's expense.

b. If there is change in aggregate source or if there is a significant change in aggregate quality from same source, submit new set of design mixes covering each class of concrete and prepare new trial batches.
c. Sieves:
    1) Use sieves with square openings for testing grading of aggregates.
    2) Sieve Analyses: If sieve analyses indicate significant change in materials, the Engineer may require that new mix design and trial batch be submitted and accepted before further placing of concrete.
d. Sample aggregate in accordance with ASTM C 136 and D 75.
e. Fine aggregate:
    1) Provide fine aggregate that does not contain strong alkali nor organic matter which gives color darker than standard color when tested in accordance with ASTM C 40.
    2) Provide aggregate having soundness complying with requirements of ASTM C 33 when tested in accordance with ASTM C 88.
    3) Provide aggregate complying with reactivity requirements of ASTM C 33 when tested in accordance with ASTM C 289.
f. Coarse aggregate:
    1) Soundness when Tested in Accordance with ASTM C 88: Have loss not greater than 10 percent when tested with sodium sulfate.
    2) Abrasion Loss: Not exceed 45 percent after 500 revolutions when tested in accordance with ASTM C 131.
    3) Reactivity: Not exceed limits specified in Appendix of ASTM C 33 when tested in accordance with ASTM C 289.
g. Portland cement:
    1) Determination alkali content: Determine by method set forth in ASTM C 114.
h. Truck delivery tickets:
    1) Neat, legible, and filled out with description of mix, additives, slump and air test results, amount of any water added, time departed concrete plant, time unloading began.

PART 3 EXECUTION

3.01 INSTALLATION

A. Liquid evaporation retardant: Under conditions which result in rapid evaporation of moisture from the surface of the concrete, immediately after the concrete has been screeded, coat the surface of the concrete with a liquid evaporation retardant. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks. Conditions which result in rapid evaporation of moisture may include one or more of the following:
    1. Low humidity.
    2. Windy conditions.
    3. High temperature.

B. Surface sealant system: Apply as recommended by manufacturer published instructions. Where concrete continues to sweat or leak, apply additional coats of surface sealant until the sweating or leaks stop.

C. Joints and bonding:
   1. As far as practicable construct concrete work as monolith.
   2. Locations of contraction construction, expansion, and other joints are indicated on the Drawings or as specified in this Section.
   3. Provide not less than 7 days between placements of concrete in adjacent concrete wall placements. Place concrete for slabs in checkerboard pattern with not less than 7 days between placements of concrete in adjacent concrete slab placements.
   4. Construction joints:
      a. Where construction joints are not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
      b. In order to preserve strength and watertightness of structures, make no other joints, except as authorized the Engineer.
      c. At construction joints, thoroughly clean concrete of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of heavy sandblasting, and wash surfaces just prior to succeeding concrete placement.
      d. At horizontal joints: Immediately prior to resuming concrete placing operations, thoroughly spread bed of grout not less than 1/2 inch in thickness nor more than 1 inch in thickness over horizontal joint surfaces.
   5. Keyways in joints:
      a. Provide keyways in joints as indicated on the Drawings.
      b. Treat lumber keyway material with form release coating, applied in accordance with manufacturer's instructions.
   6. Take special care to ensure that concrete is well consolidated around and against waterstops and waterstops are secured in proper position.
   7. Cleaning of construction joints:
      a. Wash construction joints free of sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
      b. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use vacuum cleaner for their removal, after which flush cleaned surfaces with water.
      c. Provide cleanout hole at base of each wall and column for inspection and cleaning.
   8. Contraction, construction, and expansion joints:
      a. Constructed where and as indicated on the Drawings.
      b. Waterstops, expansion joint material, synthetic rubber sealing compound, and other similar materials: As specified in Section 03150 and Section 07900.
   9. Repair of concrete: Where it is necessary to repair concrete by bonding mortar or new concrete to concrete which has reached its initial set, first coat surface of set concrete with epoxy bonding agent as specified in Section 03071.

D. Conveying and placing concrete:
   1. Convey concrete from mixer to place of final deposit by methods that prevent separation or loss of materials.
   2. Use equipment for chuting, pumping, and conveying concrete of such size and design as to ensure practically continuous flow of concrete at delivery end without separation of materials.

3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

E. Placing concrete:
1. Place no concrete without prior authorization of the Engineer.
2. Do not place concrete until:
   a. Reinforcement is secure and properly fastened in its correct position and loose form ties at construction joints have been retightened.
   b. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
   c. Forms have been cleaned and oiled as specified.
3. Placement of concrete in which initial set has occurred, or of retempered concrete, will not be permitted.
4. Place no concrete during rainstorms or high velocity winds.
5. Protect concrete placed immediately before rain to prevent water from coming in contact with such concrete or winds causing excessive drying.
6. Keep sufficient protective covering on hand at all times for protection of concrete.
7. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested and accepted by the Engineer.
8. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
   a. Provide this notification in such time in advance of operations, as the Engineer deems necessary to make final inspection of preparations at location of proposed concrete placing.
   b. Place forms, reinforcement, screeds, anchors, ties, and inserts in place before notification of readiness is given to the Engineer.
   c. Depositing concrete:
      1) Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      2) Do not deposit concrete in large quantities in one place and work along forms with vibrator or by other methods.
      3) Do not drop concrete freely into place from height greater than 5 feet.
      4) Use tremies for placing concrete where drop is over 5 feet.
      5) Commence placement of concrete on slopes, at bottom of slope.
9. Place concrete in approximately horizontal layers not to exceed 24 inches in depth and bring up evenly in all parts of forms.
10. Continue concrete placement without avoidable interruption, in continuous operation, until end of placement is reached.
11. After placement begins, it should continue without significant interruption. Precautions should be planned and implemented to prevent any delay, between layers being placed, from exceeding 20 minutes.
12. If concrete is to be placed over previously placed concrete and more than 20 minutes have elapsed, then spread layer of grout not less than 1/2 inch in thickness nor more than 1 inch in thickness over surface before placing additional concrete.

13. Placement of concrete for slabs, beams, or walkways:
    a. If cast monolithically with walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
    b. Allow set time of not less than one hour for shrinkage.

F. Consolidating concrete:
1. Place concrete with aid of acceptable mechanical vibrators.
2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the work.
3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
4. Vibrators:
    a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    b. In addition to vibrators in actual use while concrete is being placed, have on hand minimum 1 spare vibrator in serviceable condition.
    c. Place no concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.
5. Take special care to place concrete solidly against forms to leave no voids.
6. Take every precaution to make concrete solid, compact, and smooth, and if for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.

G. Footings and slabs on grade:
1. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
2. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
3. If it becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
4. Place no concrete if subgrade is muddy or soft.

H. Loading concrete:
1. Green concrete:
    a. No heavy loading of green concrete will be permitted.
    b. Green concrete is defined as concrete with less than 100 percent of the specified strength.
2. No backfill shall be placed against concrete walls, connecting slabs, or beams until the concrete has reached the specified strength.
3. Use construction methods, sequencing, and allow time for concrete to reach adequate strength to prevent overstress of the concrete structure during construction.

I. Curing concrete:
1. General:
    a. Cure concrete by methods specified in this Section.
    b. Cure concrete minimum of 7 days.
    c. Cure concrete to be painted with water or plastic membrane.
    d. Do not use curing compound on concrete surfaces that are to receive paint or upon which any material is to be bonded.

e. Water cure or plastic membrane cure concrete slabs that are specified to be sealed by concrete sealer.
f. Cure other concrete by water curing or sprayed curing membrane at the Contractor's option.
g. Floor slabs may be cured using plastic membrane curing.

2. Water curing:
   a. Keep surfaces of concrete being water cured constantly and visibly moist day and night for period of not less than 7 days.
   b. Each day forms remain in place may count as 1 day of water curing.
   c. No further curing credit will be allowed for forms in place after contact has once been broken between concrete surface and forms.
   d. Do not loosen form ties during period when concrete is being cured by leaving forms in place.
   e. Flood top of walls with water at least 3 times per day, and keep concrete surfaces moist at all times during 7 day curing period.
3. Sprayed membrane curing:
   a. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
   b. If more than 1 hour elapses after removal of forms, do not use membrane-curing compound, but use water curing for full curing period.
   c. If surface requires repairing or painting, water cure such concrete surfaces.
   d. Curing compound:
      1) Do not remove curing compound from concrete in less than 7 days.
      2) Curing compound may be removed only upon written request by the Contractor and acceptance by the Engineer, stating what measures are to be performed to adequately cure structures.
      3) Take care to apply curing compound in area of construction joints. See that curing compound is placed within construction joint silhouette.
      4) After curing period is complete, remove curing compound placed within construction joint silhouette by heavy sandblasting prior to placing any new concrete.
      5) Contractor's Option: Instead of using curing compound for curing of construction joints, such joints may be water cured.
      6) Apply curing compound by mechanical, power operated sprayer and mechanical agitator that will uniformly mix all pigment and compound.
      7) Apply compound in at least 2 coats.
      8) Apply each coat in direction 90 degrees to preceding coat.
      9) Apply curing compound in sufficient quantity so that concrete has uniform appearance and that natural color is effectively and completely concealed at time of spraying.
      10) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
      11) Thickness and coverage of curing compound: Provide compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
      12) The Contractor is cautioned that method of applying curing compound specified herein may require more compound than normally suggested by manufacturer of compound and also more than is customary in the trade.

13) Apply amounts specified herein, regardless of manufacturer's recommendations or customary practice, if curing compound is used in place of water curing.
14) If the Contractor desires to use curing compound other than specified curing compound, coat sample areas of concrete wall with proposed curing compound and also similar adjacent area with specified compound in specified manner for comparison:
a) If proposed sample is not equal or better, in opinion of the Engineer, in all features, proposed substitution will not be allowed.
15) Prior to final acceptance of the work, remove, by sandblasting or other acceptable method, any curing compound on surfaces exposed to view, so that only natural color of finished concrete is visible uniformly over entire surface.

4. Plastic membrane curing:
a. Polyethylene film may be used to cure slabs. Seal joints and edges with small sand berm.
b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
c. Keep concrete moist under plastic membrane.

3.02 CONCRETE FINISHING

A. Provide concrete finishes in accordance with Section 03366

B. Edges of joints:
1. Provide joints having edges as indicated on the Drawings.
2. Protect wall and slab surfaces at edges against concrete spatter and thoroughly clean upon completion of each placement.

3.03 FIELD QUALITY CONTROL

A. Testing of concrete:
1. During progress of construction, the Owner will have tests made to determine whether the concrete, as being produced, complies with requirements specified.
2. Tests will be performed in accordance with ASTM C 31, ASTM C 39, and ASTM C 172.
3. The Engineer will make and deliver test cylinders to the laboratory and testing expense will be borne by the Owner.
4. Required number cylinders:
a. Not less than 3 cylinder specimens, 6 inch diameter by 12 inch long, will be tested for each 150 cubic yards of each class of concrete with minimum of 3 three specimens for each class of concrete placed and not less than 3 specimens for each half day's placement.
b. One cylinder will be broken at 7 days and 2 at 28 days.
5. The Contractor shall:
a. Test slump of concrete using slump cone in accordance with requirements of ASTM C 143.
b. Furnish test equipment.
c. Do not use concrete that does not meet specification requirements in regards to slump. Remove such concrete from project site.

d. Test slump at the beginning of each placement, as often as necessary to keep slump within the specified range, and when requested to do so by the Engineer.
e. Make provisions for and furnish concrete for test specimens, and provide manual assistance to the Engineer in preparing said specimens.
f. Assume responsibility for care of and providing of curing conditions for test specimens in accordance with ASTM C 31.

B. Air entraining admixture:
1. Test percent of entrained air in concrete at beginning of each placement, as often as necessary to keep entrained air within specified range, and when requested to do so by the Engineer.
2. Provide test equipment.
3. Do not use concrete that does not meet Specification requirements for air entrainment. Remove such concrete from project site.
4. Test air entrainment in concrete in accordance with ASTM C 173.
5. The Engineer may at any time test percent of entrained air in concrete received on project site.

C. Enforcement of strength requirement:
1. Concrete is expected to reach higher compressive strength than that which is indicated in Table A as specified compressive strength f'_c.
2. Strength level of concrete: Will be considered acceptable if following conditions are satisfied:
a. Averages of all sets of 3 consecutive strength test results is greater or equal to specified compressive strength f'_c.
b. No individual strength test (average of 2 cylinders) falls below specified compressive strength f'_c by more than 500 pounds per square inch.
c. Whenever one, or both, of 2 conditions stated above is not satisfied, provide additional curing of affected portion followed by cores taken in accordance with ASTM C 42, ACI 318, and ACI 350 and comply with following requirements:
1) If additional curing does not bring average of 3 cores taken in affected area to at least specified compressive strength f'_c, designate such concrete in affected area as defective.
2) The Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcement, or replacement of defective concrete, all of the Contractor's expense.

3.04 ADJUSTING

A. Repair of defective concrete:
1. Remove and replace or repair defective work.
2. Correct defective work as specified in this Article.
3. Do not patch, repair, or cover defective work without inspection by the Engineer.
4. Provide repairs having strength equal to or greater than specified concrete for areas involved.
5. Preparation of concrete for repair:
a. Make no repair until Engineer has accepted method for preparing surface for repair.

b. Chip out and key imperfections in the work and make them ready for repair.
c. Surfaces of set concrete to be repaired: First coat with epoxy bonding agent as specified in Section 03071.

6. Methods of repair:
   a. Dry pack method:
      1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
      2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
   b. Mortar method of replacement:
      1) Use for holes too wide to dry pack and too shallow for concrete replacement.
      2) Comparatively shallow depressions, large or small, which extend no deeper than nearest surface reinforcement.
   c. Concrete replacement:
      1) Use when holes extend entirely through concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.

END OF SECTION

SECTION 03366

CONCRETE FINISHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Tooled concrete slab and wall finishes. Standard of acceptable quality will be matching (or better) appearance in comparison to similar existing structures at the site when new and existing are viewed from a distance of 20 feet.

1.02 QUALITY ASSURANCE

A. Mock-ups:
   1. Test panels for concrete finishes:
      a. Initial placement per Drawings shall serve as the test panel.
      b. Prepare test panels for F4 and F5 finishes and tie-hole repairs for review by Engineer.
      c. Accepted test panels serve as standard of quality and workmanship for project.
      d. Do not proceed with further placement until the test panel has been approved by the Engineer.
   2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
   3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
      a. Accepted test panels serve as standard for repairs during the project.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver and store packaged materials in original containers until ready for use.

PART 2 PRODUCTS

2.01 MIXES

A. Mortar mix for F4 finish: Consist of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.

B. Mortar mix for F5 finish: Consist of 1 part cement to 1-1/2 parts of sand which passes Number 16 screen.

PART 3 EXECUTION

3.01 CONCRETE FINISHES

A. Cement for finishes:
   1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.

B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
   1. F1 finish: No special treatment other than repair defective work and fill depressions 1 inch or deeper and tie holes with mortar after removal of curing compound.
   2. F2 finish: No special treatment other than repair defective work, remove fins, fill depressions 1/2 inch or deeper and tie holes with mortar after removal of curing compound.
   3. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
   4. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar.
      a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
      b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
      e. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
      f. Do not let any material remain on surfaces, except that within pits and depressions.
      g. Wipe surfaces clean and moist cure.
   5. F5 finish: Receive same finish as specified for F3 finish, and, in addition, receive special stoned finish, in accordance with following requirements:
      a. Remove forms and perform required repairs, patching, and pointing as specified in this Section.
      b. Wet surfaces thoroughly with brush and rub with hard wood float dipped in water containing 2 pounds of portland cement per gallon.
      c. Rub surfaces until form marks and projections have been removed.
      d. Spread grindings from rubbing operations uniformly over surface with brush in such manner as to fill pits and small voids.
      e. Moist cure brushed surfaces and allow to harden for 3 days:
         1) After curing, obtain final finish by rubbing with carborundum stone of approximately Number 50 grit until entire surfaces have smooth texture and are uniform in color.
         2) Continue curing for remainder of specified time.
      f. If any concrete surface is allowed to become too hard to finish in above specified manner, sandblast and wash related surfaces exposed to view, whether finished or not.
         1) While still damp, rub over surface, plastic mortar, as specified for brushed surfaces and handstoned with Number 60 grit carborundum stone, using additional mortar for brushed surfaces until surface is evenly filled without an excess of mortar.
         2) Continue stoning until surface is hard.

3) After moist curing for 3 days, make surface smooth in texture and uniform in color by use of Number 50 or Number 60 grit carborundum stone.
4) After stoning, continue curing until 7 day curing period is completed.

C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:
1. S1 finish: Screeded to grade and leave without special finish.
2. S2 finish: Smooth steel trowel finish.
3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.
4. S4 finish: Steel trowel finish, without local depressions or high points, followed by light hairbroom finish. Do not use stiff bristle brooms or brushes. Perform brooming parallel to slab-drainage. Provide resulting finish that is rough enough to provide nonskid finish. Finish is subject to review and acceptance by the Engineer.
5. S5 finish: Nonslip abrasive: After concrete has been screeded level and hardened enough to support man standing on a board, sprinkle abrasive from shake screen into surface at uniform rate of 25 pounds for each 100 square feet of surface area, wood float into finish, then trowel abrasive into surface with steel trowel properly exposing abrasive in surface as required to provide nonslip surface.

D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

3.02 CONCRETE FINISH SCHEDULE

A. Finish concrete surfaces as follows:
1. F4 finish for following vertical surfaces:
a. Concrete surfaces specified or indicated to be painted.
b. Concrete surfaces, interior or exterior, exposed to view.
2. Surfaces in open channels, basins, and similar structures:
a. F3 finish for vertical surfaces which are normally below water surface.
b. F4 finish for vertical surfaces located above normal water surface and exposed to view.
c. Remove fins and fill tie holes from concrete surfaces located in closed boxes or channels where there is normally no access or passageway.
3. S1 finish for following surfaces:
a. Projecting footings which are to be covered with dirt.
4. S2 finish for following surfaces:
a. Tops of corbels.
b. Tops of walls and beams not covered above in this Section.
c. Tops of slabs not covered above in this Section.
d. All other surfaces not specified to be finished otherwise.
5. S3 finish for following surfaces:
a. Room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.
6. S4 finish for following surfaces:
a. Exterior walkways.
b. Tops of exterior walls or beams which are to serve as walkways.

c. Tops of exterior walls or beams which are to support gratings.
d. Top surface of slabs for basins, channels, and similar structures.

END OF SECTION

SECTION 03600

GROUTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Concrete mortar.
   2. Dry-pack mortar.
   3. Epoxy grout.
   4. Grout.
   5. Non-shrink epoxy grout.
   6. Non-shrink grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch or 50-millimeter cube specimens).
   1. C 230 - Standard Specification For Flow Table For Use In Tests Of Hydraulic Cement.
   2. C 531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   3. C 579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   4. C 939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   5. C 1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-Shrink).
   6. C 1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

1.03 SUBMITTALS

A. Non-Shrink Grout: Submit manufacturer's literature and certified test data prior to installation.

B. Non-Shrink Epoxy Grout: Submit manufacturer's literature and certified test data prior to installation.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered to the jobsite in their original, unopened packages or containers, clearly labeled with the manufacturer's product identification and printed instructions.

B. All materials shall be stored in a cool dry place and in accordance with the manufacturer's recommendations.

C. All materials shall be handled in accordance with the manufacturer's instructions.

1.05 PROJECT/SITE CONDITIONS

A. Refer to manufacturer's literature or contact the manufacturer for any special physical or environmental limitations that may be required for use of products.

1.06 WARRANTIES

A. Non-Shrink Grout: The manufacturer shall warranty that the non-shrink grout will never go below its initial placement volume when tested in accordance with ASTM C 1107.

B. Non-Shrink Epoxy Grout: The manufacturer shall warranty that non-shrink epoxy grout will show negligible shrinkage or expansion when tested in accordance with ASTM C 531.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete Mortar:
   1. General: Consist of concrete mixture with coarse aggregate removed and water quantity adjusted as required.
   2. At exposed concrete surfaces not to be painted or submerged in water: White cement.

B. Dry-Pack Mortar:
   1. Consist of mixture of portland cement and sand.

C. Epoxy Grout:
   1. Consist of mixture of epoxy and sand.
   2. Sand: Clean, bagged, graded, and kiln dried silica sand.

D. Grout:
   1. Consist of mixture of portland cement and sand.

E. Non-Shrink Epoxy Grout:
   1. Manufacturers: One of the following or equal:
      a. Five Star Products, Inc., Fairfield, CT, Five Star Epoxy Grout.
      b. BASF, Inc., Cleveland, OH, Masterflow 648 CP Plus.
      c. L&M Construction Chemicals, Inc., EPOGROUT.
   2. Non-shrink epoxy grout shall be a 100 percent solid, premeasured, prepackaged system containing a 2-component thermosetting epoxy resin and inert aggregate.
   3. Consistency: Non-shrink epoxy grout shall maintain a flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Dimensional Stability (height change):
      a. Non-shrink epoxy grout shall have negligible shrinkage or expansion (less than 0.0006 inches/inch) when tested in accordance with ASTM C 531.

5. Compressive Strength: Non-shrink epoxy grout shall show a minimum compressive strength of 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C 579, Method B.
6. Compressive Creep: The compressive creep for non-shrink epoxy grout shall not exceed 0.0027 inches/inch when tested under a 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C 1181.
7. Thermal Capability: The coefficient of thermal expansion for non-shrink epoxy grout shall not exceed 0.000018 inches per inch per degree Fahrenheit when tested under ASTM C 531, Method B.

F. Non-Shrink Grout:
1. Manufacturers: One of the following or equal:
   a. Five Star Products, Inc., Fairfield, CT, Five Star Grout.
   b. BASF, Inc., Cleveland, OH, Masterflow 928.
   c. L&M Construction Chemicals, Inc., Omaha, NE, CRYSTEX.
2. Preportioned and prepackaged cement-based mixture. It shall contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings. It shall require only the addition of potable water.
3. Potable Water for Pre-Soaking, Mixing, and Curing: Clean and free of oils, acids, alkalies, organics, and any other deleterious matter.
4. Bleeding: Free from the emergence of mixing water from within or the presence of water on its surface.
5. In accordance with ASTM C 1107.
6. Consistency: Remain at a minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C 230. If at a fluid consistency, it shall be verified in accordance with ASTM C 939.
7. Dimensional Stability (height change): In accordance with ASTM C 1107, volume-adjusting Grade B or C at 45 degrees to 90 degrees. It shall show 90 percent or greater bearing area under bases or baseplates.
8. Compressive Strength: Non-shrink grout shall show minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C 1107 for various periods from the time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C 109 as modified by ASTM C 1107.

2.02 MIXES

A. Concrete Mortar Mix:
1. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
2. At Exposed Concrete Surfaces Not to Be Painted or Submerged in Water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

B. Dry-Pack Mortar Mix: Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.

C. Epoxy Grout:
1. Mix in accordance with manufacturer's installation instructions.

2. Proportioning:
    a. For Horizontal Work: Consist of mixture of 1 part epoxy as specified in Section 03071 with not more than 2 parts sand.
    b. For Vertical or Overhead Work: Consist of 1 part epoxy gel as specified in Section 03071 with not more than 2 parts sand.

D. Grout Mix:
1. For Concrete Repair: Mix in same proportions used for concrete being repaired, with only sufficient water to give required consistency for spreading.
2. For Spreading over the Surfaces of Construction or Cold Joints: Mix with no more water used than allowed by water-to-cementitious materials ratio specified for concrete.
3. For Other Applications: Mix in proportions by weight of 1 part cement to 4 parts of concrete sand.

E. Non-Shrink Epoxy Grout: Mix in accordance with manufacturer's installation instructions.

F. Non-Shrink Grout: Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and all loose material or foreign matter likely to affect the bond or performance of grout or mortar.

B. Inspect baseplate and anchor systems for rust, oil, and other deleterious substances that may affect the bond or performance of grout.

C. Confirm that newly placed concrete has been cured sufficiently to attain its design strength and limit further shrinkage.

D. Verify that temperature of cementitious or epoxy grout does not exceed manufacturer's recommendations.

3.02 PREPARATION

A. Surface Preparation:
1. Roughen all concrete surfaces by heavy sandblasting, chipping, or other mechanical means to assure bond. Loose or broken concrete shall be removed.
2. All grease, oil, dirt, curing compounds, laitance, and other deleterious materials that may affect bond that were identified in the inspection process shall be completely removed from concrete and bottoms of baseplates. All metal surfaces should have a 2 to 3 mil peak-to-valley profile for epoxy grouts.
3. For cementitious mortars and grouts, concrete shall be saturated surface damp. Any standing water shall be removed prior to placing grouts.

4. For epoxy grouts, do not wet concrete surfaces with water. Instead, where required, wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grouts.

B. Forms and Headboxes for Cementitious or Epoxy Grouts:
   1. Forms for grouts shall be built of material with adequate strength to withstand the placement of grouts.
   2. Forms must be rigid and liquid tight. All cracks and joints shall be caulked with an elastomeric sealant. All forms shall be lined with polyethylene for easy grout release. Forms carefully waxed with two coats of heavy-duty paste wax shall also be acceptable.
   3. Forms shall be 4 to 6 inches higher than the baseplate on one side of the baseplate configuration when using head pressure for placement.
   4. A sufficient number of headboxes shall be built to facilitate placement of grouts.
   5. Air relief holes a minimum 1/8-inch in diameter shall be provided when required by a baseplate configuration to avoid entrapping air underneath.

3.03 APPLICATION

A. Cement Mortar and Grout:
   1. For Defective Concrete Repair:
      a. Filling: Filling of voids around items through the concrete.
      b. Grout Spreading: Spread over construction joints, cold joints, and similar type items.
   2. Concrete Surfaces:
      a. Apply epoxy-bonding agent to clean, roughened, and dry surfaces before placing mortar or grout.
   3. Placing:
      a. Exercise particular care in placing Portland cement mortar or grout since they are required to furnish structural strength, or impermeable water seal, or both.
      b. Do not use cement mortar or grout that has not been placed within 30 minutes after mixing.

B. Epoxy Grout:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use where specified herein or where indicated on the Drawings.

3.04 PLACEMENT

A. The Contractor shall make arrangements to have a grout manufacturer's representative present for a preconstruction meeting and during initial grout placement.

B. Grout shall only be installed after the final equipment alignment is correct and accepted by the Engineer:
   1. Grouts shall be mixed in accordance with the manufacturer's recommendations.
   2. Use mortar mixer with moving paddles for mixing grouts. For cementitious grouts, pre-wet the mixer and empty out excess water before beginning mixing.

3. Cementitious Grouts:
    a. Add non-shrink cementitious grout to a premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
    b. Mix cementitious grouts per manufacturer's instructions for uniform consistency.
    c. Grouts may be drypacked, flowed, or pumped into place. All baseplate grouting shall take place from one side of a baseplate to the other to avoid trapping air. Do not overwork grouts.
    d. Do not retemper grout by adding more water after stiffening.
    e. Hydrostatic head pressure shall be maintained by keeping the level of the grout in the headbox above the bottom of the baseplate. The headbox should be filled to the maximum level and the grout worked down to top of baseplate.
4. Epoxy Grouts:
    a. Epoxy grouts shall be mixed in complete units. Do not vary the ratio of components or add solvent to change the consistency of the mix.
    b. Pour the hardener into the resin and mix for at least 1 minute and until each mixture is uniform in color. Pour the chemical components into the mortar mixer wheelbarrow and add the aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in the mix.
    c. All epoxy grout shall be flowed into place using a headbox. All grouting shall take place from one side of a baseplate to the other in a continuous flow to avoid trapping air.
    d. Hydrostatic head pressure shall be maintained by keeping the level of grout in headboxes above the bottom of baseplates. Headboxes shall be filled to the maximum level and grout worked down to the bottom of baseplates.
    e. Epoxy grouts shall not be cut back after setting. The final level of grout will be as installed with all chamfer edges built into the formwork.

3.05 CURING

A. Cementitious Grouts:
    1. Grouts must be cut back to the lower edge of baseplates after reaching initial set. Provide a 45-degree angle cut back.
    2. Clean equipment and tools as recommended by the grout manufacturer.
    3. Cure grouts in accordance with manufacturer's specifications and recommendations. Keep grout moist for a minimum of 3 days. The method needed to protect grouts will depend on temperature, humidity, and wind. Wet burlap, a soaker hose, sun shading, ponding, and, in extreme conditions, a combination of methods shall be employed.
    4. Grouts shall be maintained above 40 degrees Fahrenheit until they have attained a compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for a minimum of 24 hours to avoid damage from subsequent freezing.

B. Epoxy Grouts:
   1. Cure grouts in accordance with manufacturers' specifications and recommendations. Do not wet cure epoxy grouts.
   2. Consult the manufacturer for appropriate cure schedule. In no case should any surface in contact with epoxy grout be allowed to fall below 50 degrees Fahrenheit for a minimum of 48 hours after placement.

3.06 FIELD QUALITY CONTROL

A. Non-shrink cementitious grouts shall be tested by the Contractor for 24-hour compressive strength in accordance with ASTM C 109.

B. Non-shrink grouts shall be tested by the Contractor for 24-hour compressive strength in accordance with ASTM C 579, Method B.

END OF SECTION

SECTION 03926

STRUCTURAL CONCRETE REPAIR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Repairing damaged structural concrete.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03071 - Epoxies.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   2. C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens.
   3. C 496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C 666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   5. C 882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

1.03 SYSTEM DESCRIPTION

A. General: Structural repair concrete composed of cementitious material capable of being placed in formed vertical and overhead applications, and on horizontal surfaces.

B. Design requirements:
   1. Provide material suitable for performing in environments subject to corrosive attack by chlorides and sulfates, freeze/thaw cycles, low permeability, and abrasion resistant.
   2. Provide concrete repair mortar cement that is placeable from 1 inch in depth and extendable in greater depths.
   3. Concrete repair mortar shall be capable of being poured in place or troweled in place to suit the conditions encountered.

1.02 SUBMITTALS

A. Product data: Submit manufacturer's data completely describing structural repair concrete materials.

B. Certificates of Compliance.

C. Manufacturer's Instructions.

1.03 QUALITY ASSURANCE

A. Manufacturer qualifications: The manufacturer of the specified product shall have been in existence, for a minimum of 10 years.

B. Allowable tolerances: Deviation from plumb or level shall not exceed 1/8 inch within 10 feet in any direction, as determined with a 10-foot straight edge.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver the specified product in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.

B. Store and condition the specified product as recommended by the manufacturer.

C. Deliver, store, and handle packaged materials in the manufacturer's original, sealed containers, each clearly identified with the manufacturer's name, and name and type of product.

D. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground, and suitably protected.

1.05 PROJECT CONDITIONS

A. Existing conditions:
   1. Hot weather: ACI 305.
   2. Cold weather: ACI 306.
   3. Do not place concrete repair mortar during precipitation, unless adequate protection is provided.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural repair concrete:
   1. Manufacturers: One of the following or equal:
      a. Master Builders, “EMACO S66-CR.”
      b. Sika, "Sikatop 123 Plus."
   2. Compressive strength: As follows in accordance with ASTM C 109:
      a. 1 day: 2,500 pounds per square inch, minimum.
      b. 7 day: 6,000 pounds per square inch, minimum.
      c. 28 day: 8,000 pounds per square inch, minimum.

3. Bond strength: 2,200 pounds per square inch minimum at 28 days, in accordance with ASTM C 882 modified.
4. Slant shear bond strength: 3,300 pounds per square inch minimum at 28 days, in accordance with ASTM C 496.
5. Flexural strength: 770 pounds per square inch minimum at 28 days, in accordance with ASTM C 78.
6. Rapid freeze/thaw durability: in accordance with ASTM C 666; Procedure A.
   a. Relative durability factor at 300 cycles: 90 minimum.
7. Working time: 30 to 40 minutes.
8. Color: Concrete gray.

B. Water: Potable, clean, not detrimental to concrete.

C. Form materials:
1. Smooth finish: Match concrete finish of existing clarifiers 1 & 2, as confirmed by the Engineer.
2. Brace as required to maintain tolerances.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that concrete surfaces and exposed reinforcing are clean and free of contaminates.

3.02 PREPARATION

A. Prepare existing concrete by cleaning with steel brush and applying bonding agent in accordance with manufacturer's instructions.

B. Thoroughly clean reinforcement and other embedded items to remove loose rust and other objectionable matter.

C. Thoroughly wet wood forms, except coated plywood, and adjacent concrete at least 1 hour in advance of placing concrete; securely close cleanout end inspection ports; repeat wetting as necessary to keep forms damp.

3.03 PREPARATION

A. Damaged concrete:
1. Areas to be repaired shall be clean, sound, and free of contaminants.
   a. Remove all loose and deteriorated concrete by mechanical means acceptable to the Engineer.
   b. Saw cut perimeter 1/2-inch maximum.
2. Chip concrete substrate to obtain a surface profile of 1/16 inch to 1/8 inch in depth with a new fractured aggregate surface.
   a. The area to be repaired shall be not less than 1 inch in depth.
3. Concrete removal shall extend along the reinforcing steel to locations along the bar free of bond inhibiting corrosion, and where the bar is well bonded to surrounding concrete.

B. Use the following procedures where reinforcing steel with active corrosion is encountered:
   1. Sandblast reinforcing steel to remove all contaminants and rust.
   2. Determine section loss, splice new reinforcing steel where there is more than 15 percent loss as directed by the Engineer.
      a. If more than half the diameter of the reinforcing steel is exposed, chip out behind the reinforcing steel a minimum of 1/2 inch. The distance chipped behind the reinforcing steel must also equal or exceed the minimum placement depth of the accepted material.

C. Treat cracks in the substrate at the area of patching or overlay work as directed by the Engineer.

D. Extend existing control and expansion joints through any concrete repair.

E. Apply an epoxy-bonding agent to area to be repaired, as specified in Section 03071, prior to patching concrete with polymer-modified portland cement mortar.

3.04 MIXING

A. Mix in accordance with manufacturer's mixing instructions.

3.05 INSTALLATION

A. Formed surface finishes:
   1. Smooth finish:
      a. Obtain by the use of plywood, sheet metal, or lined wood forms; no fins, pockmarks, or other irregularities shall be present in the exposed surfaces of concrete.
      b. Place no structural repair concrete without prior authorization of Engineer.

B. Verify that form materials are in place and ready to receive installation of concrete repair material.

C. Install in accordance with manufacturer's installation instructions.

D. In accordance with ACI recommendations, apply concrete repair material only when ambient conditions of moisture, temperature, humidity, and wind are favorable for curing.

E. Scrub mortar into substrate, filling all cracks, voids, and pores.

F. For new construction, finish of repaired area shall match required finish for concrete being repaired.

G. For existing concrete, finish of repair area shall match finish of concrete being repaired.

H. During the curing process, protect concrete repair from rain, wind, or freezing as required.
   1. Keep sufficient covering on hand at all times for protection of repair concrete.

3.06 CLEANING

A. Remove debris and excess material. Leave work site in a neat, clean condition.

END OF SECTION

SECTION 03931

EPOXY INJECTION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy injection system.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 638 - Standard Test Method for Tensile Properties of Plastics.
   2. D 695 - Standard Test Method for Compressive Properties of Rigid Plastics.
   3. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SUBMITTALS

A. Product data: Submit manufacturer's data completely describing epoxy injection system materials.

B. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Manufacturers: One of the following or equal:
   1. Master Builders, Inc., Concressive Standard LVI.
   2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.

B. Epoxy:
   1. Provide epoxy materials that are new and use them within shelf-life limitations set forth by manufacturer.
   2. Water-insensitive 2-part type low viscosity epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

Physical Characteristic	Test Method	Required Results
Tensile Strength	ASTM D 638	8,000 pounds per square inch at 14 days.
Flexure Strength	ASTM D 790	11,000 pounds per square inch at 14 days.
Compressive Strength	ASTM D 695	11,000 pounds per square inch at 24 hours.
Bond Strength	--	Concrete shall fail before failure of epoxy.
Gel Time for 5 Mil Film	--	4 hours maximum.
Elongation	ASTM D 638	1 percent minimum at 14 days.

2.02 EQUIPMENT

A. Pump unit:
   1. Furnish unit to be used for injection that is positive displacement type with interlock to provide in-line mixing and metering system for 2 component epoxy.
   2. Furnish pressure hoses and injection nozzle of such design as to allow proper mixing of 2 components of epoxy.
   3. Presence of standby injection unit may be required.

2.03 MIXES

A. Epoxy injection system materials:
   1. Mix epoxy in accordance with manufacturer's installation instructions.
   2. Do not use solvents to thin epoxy system materials introduced into cracks or joints.

PART 3 EXECUTION

3.01 PREPARATION

A. Surface preparation:
   1. Epoxy injection system:
      a. General: Before processing, sweep or clean area in vicinity of crack location to receive epoxy and leave in generally clean condition.
      b. Joints to receive epoxy: Clean in manner such that joints are free from dirt, laitance, and other loose matter.

3.02 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Perform and conduct work of this Section in neat, orderly manner.

C. Epoxy injection system:
   1. Apply adequate surface seal to crack or joint to prevent escape of epoxy.
   2. Establish injection points at distance along seal not less than thickness of cracked member.
   3. Inject epoxy into crack at first port with sufficient pressure to advance epoxy to adjacent port.
   4. Seal original port and shift injection to port at which epoxy appears.

5. Continue this manner of port-to-port injection until each joint has been injected for its entire length.
6. For small amounts, or where excessive grout pressure developed by pump unit might further damage structure, premixed material and hand caulking gun may be used if acceptable to the ENGINEER.
7. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
8. After epoxy injection is complete, remove surface seal material and refinish concrete in area where epoxy was injected to match existing concrete.

END OF SECTION

SECTION 03936

WATER LEAKAGE TEST FOR CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Leakage test for concrete water holding structures.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03931 - Epoxy Injection System.
      b. Section 07900 - Joint Sealants.

1.02 SUBMITTALS

A. Shop drawings: Leak repair methods.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 WATER LEAKAGE TEST

A. Test the following concrete water holding structures for leakage:
   1. New pump station.

B. Sequencing:
   1. Water leakage test shall be performed prior to:
      a. Grout installation where applicable.
      b. Caulking as indicated on the Drawings or as specified in Section 07900.

C. Before testing water holding structures for leakage:
   1. Backfill excavations to top of structure foundations.
   2. Cure concrete and obtain specified concrete compressive strength.
   3. Do not apply facing or other materials that will cover concrete surfaces until after testing water holding structures for leakage.

D. Isolate sections of water holding structures that can be isolated in actual operation. Test sections separately for leakage.

E. Close valves and gates to structures.

F. Fill water-holding structures with water to maximum liquid level indicated on the Drawings.

G. Make other equipment such as stop gates, sluice gates, valves, and temporary bulkheads watertight or measure leakage through other equipment by methods acceptable to Engineer. Do not base leakage upon manufacturer's estimates.

H. Determine evaporation by floating evaporation pans in structures during testing.

I. Examine concrete surfaces for leaks and damp spots during first 24 hours after filling structures.

J. When leaks or damp spots appear on exposed surfaces:
   1. Mark visible leaks and damp spots.
   2. Drain structures of water after minimum 24 hours of being full.
   3. Repair defects causing leaks and damp spots by epoxy injection as specified in Section 03931 on both interior and exterior of structures.
   4. Refill water-holding structures.
   5. Repeat testing and repair process until no leaks or damp spots appear.

K. When no leaks or damp spots appear after 24 hours of being full, measure change in water volume during the next 24 hours.

L. When water volume loss exceeds 0.10 percent of water volume originally held with allowance for equipment leakage, evaporation, and precipitation:
   1. Determine cause of volume loss.
   2. Drain structures of water.
   3. Repair defects causing loss of water volume.
   4. Refill water-holding structures.
   5. Repeat testing and repair process until volume loss does not exceed 0.10 percent of water volume originally held in 24 hours.

END OF SECTION

SECTION 04055

EPOXY BONDING REINFORCING BARS AND ALL THREAD RODS IN MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in masonry using epoxy adhesive.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 03200 - Concrete Reinforcing.
      c. Section 05120 - Structural Steel.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

B. ASTM international (ASTM):
   1. C 881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

C. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

D. Society for Protective Coatings (SSPC):
   1. Surface Preparation Standards (SP)
      a. SP-1 - Solvent Cleaning.

1.03 SUBMITTALS

A. Product Data: Furnish technical data for epoxy adhesives, including:
   1. Installation instructions.
   2. Independent laboratory test results.
   3. Handling and storage instructions.

B. Quality control submittals:
   1. Epoxy manufacturer's past project experience data on at least 3 similar projects supplied with proposed products within the last 3 years.
   2. Special inspection: Provide detailed step-by-step instructions for the special inspection procedure in accordance with the building code as specified in Section 01410.
   3. ICC Evaluation Service, Inc., Evaluation Services Report in compliance with the AC308-Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection.
   1. Store epoxy components on pallets or shelving in a covered-storage area.
   2. Control temperature above 60 degrees Fahrenheit and dispose of product if shelf life has expired.
   3. If stored at temperatures below 60 degrees Fahrenheit, test components prior to use to determine if they still meet specified requirements.

1.05 PROJECT CONDITIONS

A. Seismic design criteria: Refer to Section 01612.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

2.02 EPOXY ADHESIVE FOR SELF-CONTAINED CARTRIDGE SYSTEM

A. Epoxy adhesive shall have a current ICC Evaluation Service report documenting acceptance under AC308 for use with cracked concrete and for the seismic design categories specified.

B. Materials
   1. In accordance with ASTM C 881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture, and gray in color.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

C. Packaging.
   1. Furnished in side-by-side cartridges with resin and hardener components isolated until mixing through manufacturer’s static mixing nozzle. Nozzle designed to thoroughly blend the components for injection from the nozzle directly into prepared hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

D. Manufacturers: One of the following or equal:
   1. Hilti, Inc., Tulsa, OK: RE 500-SD .
   2. Simpson Strong-Tie Company, Inc., Pleasanton, CA: SET-XP.

2.03 ALL THREAD RODS

A. Materials: As specified in Section 05120.

2.04 REINFORCING BARS

A. As specified in Section 03200.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Epoxy Adhesive Packaged as Follows:
   1. Disposable, self-contained cartridge system capable of dispensing both epoxy components in the proper mixing ratio, and fit into a manually or pneumatically operated caulking gun.
   2. Dispense components through a mixing nozzle that thoroughly mixes components.

3.02 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a “condition of use” in the ICC Evaluation Report submitted.
   3. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.
   4. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

C. Hole diameter: Reinforcing bar diameter or all thread rod diameter plus 1/8 inch.

D. Obstructions in drill path:
   1. If an existing reinforcing bar or other obstruction is hit while drilling hole, stop drilling hole and fill the hole with drypack mortar. Relocate the hole to miss the obstruction and drill another hole. Repeat the above until the hole has been drilled to the required depth.
   2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the structural member and endanger the stability of the structure. Drypack holes which hit obstructions and allow

drypack to reach strength equal to the existing concrete before drilling adjacent holes. Epoxy grout may be substituted for drypack when acceptable to Engineer.

3. When existing reinforcing steel is encountered during drilling and when acceptable to Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter.
4. Bent bar reinforcing bars: Where edge distances are critical, and striking reinforcing steel is likely, and if acceptable to Engineer, drill hole at 10 degree angle or less from axis of reinforcing bar or all thread rod being installed.

E. Install reinforcing bars and all thread rods to depth, spacings, and locations as indicated on the Drawings or in the Specifications.
   1. Do not install epoxy bonded all-thread rods or reinforcing bars in overhead applications.

F. Cleaning holes:
   1. Insert long air nozzle into hole and blow out loose dust. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
   2. Use a stiff bristle brush to vigorously brush hole to dislodge compacted drilling dust.
   3. Repeat step 1.
   4. Repeat above steps as required to remove drilling dust or other material that will reduce bond. The hole shall be clean and dry.

G. Cleaning reinforcing bars and all thread rods:
   1. Solvent clean reinforcing bar and all thread rods over the embedment length in accordance with SSPC SP-1 Solvent Cleaning. Provide an oil and grease free surface to promote bonding of adhesive to steel.
   2. Clean reinforcing bars and all thread rods over embedment length to bare metal. The reinforcing bars and all thread rods shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.

H. Filling hole with epoxy:
   1. Fill hole with epoxy before inserting the reinforcing bar or all thread rod. Fill hole with epoxy starting from bottom of hole. Fill hole without creating air voids.
   2. Fill hole with sufficient epoxy so that excess epoxy is extruded out of the hole when the reinforcing bar or all thread rod is inserted into the hole.
   3. Do not install epoxy prior to receiving epoxy manufacturer's onsite training.

3.03 MANUFACTURERS' SERVICES

A. Furnish manufacturer's representative to conduct jobsite training for proper installation, handling, and storage of epoxy, for personnel who will perform actual installation. Engineer may attend training sessions.

3.04 FIELD QUALITY CONTROL

A. Testing laboratory or site inspector hired by Owner will:
   1. Review epoxy manufacturer’s recommended special inspection procedures.
   2. Periodically inspect hole-drilling operations for conformance with Contract Documents and manufacturer’s recommendations.

3. Certify in writing to the Engineer that depth and location of holes conform to the requirements in the Contract Documents prior to placement of epoxy.
4. Continuously inspect placement of epoxy and reinforcing bars installation.

END OF SECTION

SECTION 04090

MASONRY ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Adjustable Wall Ties.
   2. Control Joint Filler.
   3. Reinforcing Bars.
   4. Sheet Metal Ties.
   5. Wall Tie Screws.
   6. Water Repellent.
   7. Wire Joint Reinforcement, Single Wythe Type.
   8. Loose Fill Insulation.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   2. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   4. A 641 - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
   5. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
   6. D 2287 - Standard Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds.

1.03 SUBMITTALS

A. Shop drawings.

B. Product data.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Adjustable Wall Ties: 2-piece zinc coated fabrications, minimum 3/16-inch diameter steel wire formed into hook or pin and eye pieces, capable of restraining compression and tension forces from veneer:
   1. Manufacturers: One of the following or equal:
      a. AA Wire Products Co., AA303.
      b. Dur-O-Wal, Inc., D/A 515.

c. Wire-Bond, 1800 Hook and 1801 Eye.

B. Control Joint Filler: The key shall be of the width and shape as indicated on the Drawings. In accordance with ASTM D 2000 or ASTM D 2287:
   1. Manufacturers: One of the following or equal:
      a. AA Wire Products, Inc., AA2000 Blok-Tite.
      b. Dur-O-Wall, Rapid Poly-Joint.
      c. Vert-A-Joint Co., Vert-A-Joint.

C. Reinforcing Bars: In accordance with ASTM A 615, Grade 60, deformed billet steel bars.

D. Sheet Metal Ties: Unless shown otherwise on the Drawings, minimum 20 gauge corrosion resistant corrugated sheet metal, minimum 7/8 inch wide by 7 inches long, pre-punched for wire ties to wire joint reinforcement.

E. Wire Joint Reinforcement, Single Wythe Type: Consisting of ASTM A 82, 9-gauge wire side rails and cross ties, sized to suit application, galvanized in accordance with ASTM A153, Class B, 1.5 ounce of zinc per square foot.

F. Wire Joint Reinforcement, Single Wythe Type: In accordance with ASTM A 82, 9-gauge wire side rails and ladder-type cross ties, sized to suit application, galvanized in accordance with ASTM A 641:
   1. Manufacturers: One of the following or equal:
      a. AA Wire Products, Co., AA500 Blok-Lok.
      b. Dur-O-Wal, Inc., Ladur-type.
      c. Wire-Bond, Ladder Type.

G. Loose Fill Insulation:
   1. Perlite in accordance with ASTM C549, Type IV, Surface-treated for water repellency and to limit dust generation during installation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products as specified in Section 04220.

END OF SECTION

SECTION 04100

MORTAR AND MASONRY GROUT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Mortar and masonry grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 144 - Specification for Aggregate for Masonry Mortar.
   2. C 150 - Specification for Portland Cement.
   3. C 207 - Specification for Hydrated Lime for Masonry Purposes.
   4. C 270 - Specification for Mortar for Unit Masonry.
   5. C 404 - Specification for Aggregates for Masonry Grout.
   6. C 476 - Specification for Grout for Masonry.
   7. C 780 - Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.
   8. E 329 - Specifications for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

B. International Code Council (ICC):
   1. International Building Code (2006 IBC) Standards.

1.03 DEFINITIONS

A. Alkali: Sum of sodium oxide and potassium oxide calculated as sodium oxide.

1.04 PERFORMANCE REQUIREMENTS

A. Compressive Strength:
   1. Mortar: Minimum 1,800 pounds per square inch at 28 days.
   2. Grout: Minimum 2,000 pounds per square inch at 28 days.

1.05 SUBMITTALS

A. Product Data.

B. Shop Drawings.

C. Samples: Include mortar color channels.

D. Design Data: Design Mixes for mortar and grout.

E. Test Reports:
   1. Mortar Strength Test Results.
   2. Grout Strength Test Results.

1.06 QUALITY ASSURANCE

A. Materials for Mortar and Grout: Do not change source of materials which will affect the appearance of finished work after the work has started unless acceptable to Engineer.

1.07 PROJECT CONDITIONS

A. Environmental Requirements:
   1. Cold weather requirements:
      a. In accordance with the International Building Code Cold Weather Construction.
      b. Provide adequate equipment for heating mortar and grout materials when air temperature is below 40 degrees Fahrenheit. Temperatures of separate materials, including water, shall not exceed 140 degrees Fahrenheit when placed in mixer. Maintain mortar temperature on boards above freezing.
   2. Hot weather requirements: Wet mortar board before loading and cover mortar to retard drying when not being used.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials for Mortar and Grout: Do not change source at materials which will affect appearance of finished work after the work has started unless acceptable to Engineer.

B. Portland Cement: ASTM C 150, Type II, low alkali, containing maximum 0.6 percent total alkali.

C. Hydrated Lime: ASTM C 207, Type S.

D. Fine Aggregate: ASTM C 144, sand.

E. Coarse Aggregate: ASTM C 404, coarse, size Number 8.

F. Water: Clean, clear and potable, free of oil, soluble salts, chemicals, and other deleterious substances.

G. Grout Admixture: One of the following or equal:
   1. Sika Grout Aid, Type II.
   2. Concrete Emulsions, GA-II.

H. Mortar Admixture: One of the following or equal:
   1. Sika Proof 85.
   2. W.R. Grace, dry block mortar.

2.02 MORTAR

A. Mortar Mixing:
   1. Mix on jobsite in accordance with ASTM C 270, Type S, to meet performance requirements.
   2. Mix in mechanical mixer and only in quantities needed for immediate use.
   3. Mix for minimum 3 minutes, and maximum of 5 minutes after materials have been added to mixer.

B. Measurement for ingredients for mortar shall be either by volume or weight. Measure by one of the following methods:
   1. Measurement by volume: If ingredients are measured by volume, measurement of sand shall be accomplished by the use of a container of known capacity.
   2. Shovel count.
   3. Measurement by weight: If ingredients are measured by weight, measurement of sand shall be based on the dry weight of sand of 80 pounds per cubic foot.

C. Water shall be mixed with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the vertical surfaces of masonry units.
   1. Use no mortar which has been standing for more than 1 hour after being mixed.
   2. Whenever 90 minutes has elapsed since last batch was mixed, completely empty mixer drum of materials and wash down before placing next batch of materials.

2.03 GROUT

A. Grout Mixing:
   1. Mix on jobsite in accordance with ASTM C 476 or in transit mixer to meet performance requirements with 8 to 10 inch slump.
   2. Use within 90 minutes after addition of mixing water.
   3. Mix for minimum of 5 minutes after ingredients are added and until uniform mix is attained. Grout shall have sufficient water added to produce pouring consistency without segregation.

B. Mix grout with coarse aggregate for cavity walls with horizontal dimension of 2 inches or more, and hollow cell masonry units with minimum 4-inch cell dimensions in both horizontal directions.

2.04 SOURCE QUALITY CONTROL

A. Mortar Strength Testing:
   1. Perform compressive strength tests on trial batches of mortar in accordance with IBC Section 2105 by an independent testing laboratory acceptable to the Engineer.
   2. Cost of tests shall be paid by the Contractor.

B. Grout Strength Testing:
   1. Perform compressive strength tests in trial batches of grout in accordance with IBC Section 2105 by an independent testing laboratory acceptable to the Engineer.
   2. Cost of tests shall be paid by the Contractor.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 04220. Use clean-outs at the base of each CMU cell grouted if the height of the grout lift exceeds 56 inches.

3.02 FIELD QUALITY CONTROL

A. Test mortar in accordance with ASTM C 780.
   1. Make at least 2 test specimens of mortar and grout per week.
   2. Make at least 2 test specimens of mortar and grout for each floor level of masonry laid.

B. Mortar shall be proportioned to the requirements of ASTM C270. As long as it is proportioned to this, no further qualifications are required. If C270 not met, test to ASTM C780.

C. Grout shall be manufactured to the requirements of ASTM C476, tested to the requirements of ASTM C1019. The mix needs to be tested before approval and tested at the jobsite.

END OF SECTION

SECTION 04220

CONCRETE MASONRY UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Concrete masonry units and accessories.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C 90 - Standard Specification for Loadbearing Concrete Masonry Units.
   2. C 140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   3. C 426 - Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units.

B. Section 04090 - Masonry Accessories.

1.03 DEFINITIONS

A. Standard Level of Quality: High quality, but conventional, nearly free of chips, cracks or other imperfections detracting from appearance when discernible and identified from distance of 20 feet under diffused lighting. Where level of quality is not specified, Standard Level of Quality shall be assumed.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer’s product data for split face block.

B. Samples: Include samples of stretcher units in sufficient quantity to illustrate color range.

C. Test Reports:
   1. Compressive strength.
   2. Linear shrinkage.
   3. Moisture content as a percentage of total absorbtion.
   4. Total absorbtion.
   5. Unit weight.

D. Submit 30-inch x 42-inch drawings showing the size, spacing, and splice locations of cmu reinforcement. Copies of contract drawings such as architectural building elevations with the rebar and notes neatly penciled will be accepted.

1.05 QUALITY ASSURANCE

A. Mock-Up:
   1. Prior to starting construction of masonry, construct minimum 4-foot square mock-up using standard level of quality.

2. Use accepted materials, containing each different kind and color of concrete masonry units to illustrate wall design.
3. When not accepted, construct another mock-up.
4. When accepted, mock-up will be standard of comparison for remainder of masonry work.
5. Upon completion of Project, dispose of mock-ups in legal manner at offsite location.

B. Pre-Installation Conference: Conduct as specified in Section 01312.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Transport and handle concrete masonry units as required to prevent discoloration, chipping, and breakage.

B. Store masonry units off the ground in a dry location, covered and protected from absorbing moisture. Locate storage piles, stacks, and bins to protect materials from heavy traffic.

C. Remove chipped, cracked, and otherwise defective units from jobsite upon discovery.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Cold Weather Requirements:
1. In accordance with building code as specified in Section 01410, provide adequate equipment for heating masonry materials when air temperature is below 40 degrees Fahrenheit.

B. Hot Weather Requirements:
1. In accordance with building code as specified in Section 01410, when ambient air temperature exceeds 100 degrees Fahrenheit, or when ambient air temperature exceeds 90 degrees Fahrenheit and wind velocity is greater than 8 miles per hour, implement hot weather protection procedures.
2. Wet mortar board before loading and cover mortar to retard drying when not being used.
3. Do not spread mortar beds more than 48 inches ahead of placing masonry units.
4. Place masonry units within one minute of spreading mortar.

1.08 SEQUENCING AND SCHEDULING

A. Order concrete masonry units well before start of installation to ensure adequate time for manufacturing and minimum 28 days for curing and drying before start of installation. Protect from weather after curing period to avoid moisture increase.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Hollow Load Bearing Concrete Masonry Units:

1. Class: Class 3 in accordance with ASTM C 90, Type I, Standard Level of Quality, with minimum compressive strength of 1,900 pounds per square inch.
2. Surface Textures: Split-face and standard with dense faces suitable for painting where scheduled to be painted.
3. Color: Integral, selected from manufacturer's complete line of color selection.
4. Typical Sizes: 8 inches wide by 8 inches high by 16 inches long, 12 inches wide by 8 inches high by 16 inches long, and other sizes as indicated on the Drawings.
5. Special Sizes and Shapes: As required for window and door openings, bond beams, piers, lintels, control joints, and other special applications to minimize cutting.
6. Manufacturers: The following or equal:
    a. Western Block Co., Phoenix, AZ.

B. Anchor Bolts: As specified in Section 05120.

C. Steel Reinforcement: As specified in Section 04090.

D. Wall Ties: As specified in Section 04090.

E. Wire Joint Reinforcement: As specified in Section 04090.

PART 3 EXECUTION

3.01 PREPARATION

A. Protection:
1. Protect adjacent construction with appropriate means from mortar droppings and other effects of laying of concrete masonry units.

B. Surface Preparation:
1. Thoroughly clean foundations of laitance, grease, oil, mud, dirt, mortar droppings, and other matter that will reduce bond.

3.02 INSTALLATION

A. Forms and Shores:
1. Where required, construct forms to the shapes indicated on the Drawings:
    a. Construct forms sufficiently rigid to prevent deflection which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout.
    b. Do not remove supporting forms or shores until the supported masonry has acquired sufficient strength to support safely its weight and any construction loads to which it may be subjected.
        1) Wait at least 24 hours after grouting masonry columns or walls before applying uniform loads.
2. Wait at least 72 hours before applying concentrated loads.

B. Concrete Masonry Units:
1. Provide Standard Level of Quality.
2. Lay concrete masonry units dry, without any visible surface moisture.

3. Lay units in uniform and true courses, level, plumb, and without projections or offset of adjacent units.
4. Lay units to preserve unobstructed vertical continuity of cells to be filled with grout or insulation.
5. Align vertical cells to be filled with grout to maintain clear, unobstructed continuous vertical cell measuring not less than 2 by 3 inches.
6. Place mortar with full coverage of joints at webs of all cells and face shells.
7. Butter vertical head joints for thickness equal to face shell thickness of units, and shove joints tightly together so that mortar bonds to both masonry units.
8. Solidly fill joints from face of units to inside face of cells.
9. Lay units to desired height with joints of uniform thickness.
10. Bond shall be plumb throughout.
11. Lay units to avoid formation of cracks when units are placed. Keep cells of units as free of mortar as possible as masonry wall height increases.
12. When positions of units shift after mortar has stiffened, bond is broken, or cracks are formed, relay units in new mortar.
13. Remove mortar, mortar droppings, debris, and other obstructions and materials from inside of cell walls to receive grout.
14. Seal cleanouts after inspection and before grouting.

C. Bond Pattern:
   1. Lay concrete masonry units in running bond pattern, unless otherwise indicated on the Drawings.

D. Mortar Joints:
   1. Make joints straight, clean, smooth, and uniform in thickness.
   2. Tool exposed joints, slightly concave. Strike concealed joints flush. See Architectural exterior elevations for special tooled joint locations.
   3. Make vertical and horizontal joints 3/8-inch thick.
   4. Where fresh masonry joins totally or partially set masonry, clean and roughen set masonry before laying new units.

E. Wire Joint Reinforcement:
   1. Lap splice longitudinal wire joint reinforcement minimum 75 wire diameters.
   2. Place longitudinal wires in approximate centers of mortar beds with minimum 5/8-inch mortar cover on exposed faces.
   3. Provide intersecting masonry walls with prefabricated wire joint reinforcement tees.
   4. Rake intersecting joints 1/2 inch and caulk joints.

F. Grouting and Reinforcement:
   1. Where horizontal and vertical bars are spliced and adjacent lap splices are separated by more than 3 inches, the lap splice length shall be 72 bar diameters. Where adjacent lap splices are separated by 3 inches or less, the lap splice length shall be increased by 1.3 times or the lap splices shall be staggered at least 24 bar diameters with no increase in length.
   2. Hold vertical reinforcing bars in position at top and bottom and at intervals not exceeding 200 bar diameters. Use steel wire bar positioners to position bars. Tie reinforcing bars to dowels with wire ties.
   3. Obtain acceptance of reinforcement placement before grouting.
   4. Fill all spaces and cells solidly with grout.
      a. Low-Lift Grouting:

1) Hollow unit masonry to be grouted by the low lift method shall be constructed and grouted in lifts not exceeding 5 feet.
2) Slushing with mortar will not be permitted.

b. High-Lift Grouting:
1) Hollow unit masonry shall be allowed to cure at least 24 hours before grouting.
2) Grout shall be placed in lifts not to exceed 6 feet in depth.
3) Each lift shall be allowed to set for 10 minutes after initial consolidation of grout before successive lift is placed.
4) The full height of each section of wall shall be grouted in one day.

5. Grout in cells shall have full contact with surface of concrete footings.
6. When grouting stops for one hour or longer, form horizontal construction joints by stopping grout placement 1-1/2 inches below top of uppermost unit containing grout.
7. After placement, consolidate grout using mechanical immersion vibrators designed for consolidating grout.
8. Placement:
a. Use a hand bucket, concrete hopper, or grout pump.
b. Place grout in final position within 1-1/2 hours after mixing. Place grout so as to completely fill the grout spaces without segregation of the aggregates.
c. Do not insert vibrators into lower grout placements that are in a semi-solidified state.

G. Bond Beams:
1. Place horizontal reinforcement and solidly grout bond beam units in place.
2. Provide wire mesh at openings in bottom of bond beams to support grout where walls are not grouted solid.
3. As shown in Typical Details for connections to underside of roof and floor decks, ensure the embedded steel plate is at the correct elevation to fasten the metal deck.

H. Cutting Concrete Masonry Units:
1. When possible, use full units of the proper size in lieu of cut units. Cut units as required to form chases, openings, for anchorage, and for other appurtenances.
2. Cut and fit units with power-driven carborundum or diamond disc blade saw.

I. Control Joints:
1. Provide in masonry walls at locations indicated on the Drawings.
2. Make full height and continuous in appearance.
3. Run bond beams and bond beam reinforcing bars continuously through control joints.
4. Insert control joint filler in joints as wall is constructed.
5. Apply sealant as specified in Section 07900.

J. Openings and Lintels:
1. Place horizontal reinforcement in fully grouted bond beam units.
2. Use lintel block units where underside of lintel will be exposed.
3. Provide minimum of 8-inch bearing at each end of lintel.

4. Embed reinforcing bars minimum 24 inches or 48 bar diameters, whichever is longer, into wall past edges of openings or as indicated on the Drawings:
    a. At corners, provide 90-degree bend with equivalent total embedment.

K. Steel Door Frames:
1. Anchor and fully grout jambs and head of steel door frames connected to concrete unit masonry.
2. Fill frames with grout as each 2 feet of concrete unit masonry is laid.

L. Bearing Plates:
1. Provide minimum of 12 inches of grouted concrete unit masonry below steel bearing plates and beams bearing on masonry walls.

M. Anchor Bolts:
1. Hold anchor bolts in place with template during grouting to assure precise alignment.
2. Do not cut or ream members being anchored or use other means to accommodate misaligned anchor bolts in roof deck support angles.
3. Provide minimum 6-inch wide grouted concrete unit masonry entirely around anchor bolts and other attachment devices.

N. Enclosures:
1. Where concrete masonry units enclose conduit, pipes, stacks, ducts, and similar items, construct chases, cavities, and similar spaces as required, whether or not such spaces are indicated on the Drawings.
2. Point openings around flush mounted electrical outlet boxes with mortar, including flush joints above boxes.
3. Do not cover enclosures until inspected and when appropriate, tested.

O. Other Embedded Items:
1. Build in wall plugs, accessories, flashings, pipe sleeves, and other items required to be built-in as the masonry work progresses.

P. Patching:
1. Patch exposed concrete masonry units at completion of the Work and in such manner that patching will be indistinguishable from similar surroundings and adjoining construction.

Q. Water Curing:
1. Protect concrete masonry units from drying too rapidly by frequently fogging or sprinkling so walls will always be visibly damp for minimum 3 days.

R. Miscellaneous:
1. Build in required items, such as anchors, flashings, sleeves, frames, structural steel, lintels, anchor bolts, and metal fabrications, as required for complete installation.

S. Water Repellent:
1. Apply water repellent as specified in Section 07190.

T. Grouting Equipment:
   1. Grout Pumps:
      a. Do not pump grout through aluminum tubes.
      b. Operate pumps to produce a continuous stream of grout without air pockets.
      c. Upon completion of each days pumping, eject grout from pipeline without contamination or segregation of the grout:
         1) Remove waste materials and debris from the equipment.
         2) Dispose of waste materials, debris, and all flushing water outside the masonry.
   2. Vibrators:
      a. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the grout.
      b. Maintain at least 1 spare vibrator, at the site at all times.
      c. Apply vibrators at uniformly spaced points not further apart than the visible effectiveness of the machine.
      d. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

3.03 CONSTRUCTION

A. Site Tolerances: Lay masonry plumb, true to line, and with courses level. Keep bond pattern plumb throughout. Lay masonry within the following tolerances:
   1. Maximum variation from the plumb in the lines and surfaces of columns, walls, and in the flutes and surfaces of fluted or split faced blocks:
      a. In adjacent masonry units: 1/8-inch.
      b. In 10 feet: 1/4-inch.
      c. In any story or 20 feet maximum: 3/8-inch.
      d. In 40 feet or more: 1/2-inch.
   2. Maximum variations from the plumb for external corners, expansion joints, and other conspicuous lines:
      a. In any story or 20 feet maximum: 1/4-inch.
      b. In 40 feet or more: 1/2-inch.
   3. Maximum variations from the level or grades indicated on the Drawings for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
      a. In any bay or 20 feet maximum: 1/4-inch.
      b. In 40 feet or more: 1/2-inch.
   4. Maximum variations of the linear building lines from established position in plan and related portion of columns, walls, and partitions:
      a. In any bay or 20 feet maximum: 1/2-inch.
      b. In 40 feet or more: 3/4-inch.
   5. Maximum variation in cross sectional dimensions of columns and in thickness of walls:
      a. Minus: 1/4-inch.
      b. Plus: 1/2-inch.

3.04 FIELD QUALITY CONTROL

A. Site Tests:
   1. Contractor will have tests performed by an independent laboratory.

2. Have minimum 3 concrete masonry units of each type proposed for Project tested in accordance with ASTM C 90, C 140, and C 426 to verify conformance to Specifications.
3. Tests shall include compressive strength, linear shrinkage, moisture content as percent of total absorption, total absorption, and unit weight.

B. Special Inspection:
1. Special inspection by Owner shall be as specified in Section 01455.
2. Owner will employ a qualified masonry special inspector for continuous special inspection of the masonry work. The masonry inspector shall be at the site during all masonry construction and perform the following duties:
   a. Review Drawings and Specifications and meet with the Contractor to discuss requirements before work commences.
   b. Before masonry work commences, Contractor and the Contractor's Quality Control Representative shall attend meeting with Engineer to review the requirements for surveillance and quality control of the masonry work.
   c. Check brand and type of cement, lime (if used), and source of sand.
   d. Verify that foundation is clean, rough, and ready to receive units.
   e. Check reinforcing steel dowels for correct location, straightness, proper alignment, spacing, size, and length.
   f. Observe field proportioning of mortar. Visually check aggregate to determine uniformity of grading, cleanliness, and moisture.
   g. Verify that joints are full of mortar and kept tight during work. Inspect grout cells to verify that fins will not interfere with grouting. Verify that masons keep grout cells clean of mortar droppings and inspect to determine compliance.
   h. Continuously observe placing of grout.
   i. Perform or supervise performance of required sampling and testing.
3. Keep complete record of inspections. Report daily to the Building Official, Contractor's Quality Control Representative, Engineer, and Owner the progress of the masonry inspection.

3.05 CLEANING

A. Exercise extreme care to prevent mortar splotches.

B. Do not attach construction supports to concrete masonry walls.

C. Wash off concrete scum and grout spills before scum and grout set.

D. Remove grout stains from walls.

E. Clean exposed masonry. Remove scaffolding and equipment. Dispose of debris, refuse, and surplus material offsite legally.

F. Remove efflorescence on exposed surfaces with commercially prepared cleaning solution acceptable to masonry unit manufacturer:
1. Apply cleaning solution in accordance with cleaning solution manufacturer's printed instructions.
2. Do not use muriatic acid as cleaning solution.
3. Do not use high pressure cleaning equipment.

3.06 PROTECTION

A. Provide temporary protection for exposed masonry corners subject to damage.

B. Bracing:
   1. Unless wall is adequately supported by permanent supporting elements so wall will not overturn or collapse, adequately brace masonry walls over 8 feet in height to prevent overturning and to prevent collapse.
   2. Keep bracing in place until permanent supporting elements of structure are in place.

C. Limited Access Zone:
   1. Establish limited access zone prior to start of masonry wall construction.
   2. Zone shall be immediately adjacent to wall and equal to height of wall to be constructed plus 4 feet by entire length of wall on unscaffolded side of wall.
   3. Limit access to zone to workers actively engaged in constructing wall. Do not permit other persons to enter zone.
   4. Keep zone in place until wall is adequately supported or braced by permanent supporting elements to prevent overturning and collapse.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural steel shapes and plate.
   2. Fasteners:
      a. Anchor bolts.
      b. Assembly bolts.
      c. Concrete inserts.
      d. High strength bolts.
      e. Powder actuated fasteners.
      f. Sleeve anchors.
      g. Welded studs.
   3. Isolation sleeves and washers.
   4. Thread coating.
   5. Welding.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01455 - Special Tests and Inspections.
      b. Section 03055 - Epoxy Bonding Reinforcing Bars and All Thread Rods In Concrete.
      c. Section 09960 - Coatings.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. Specification for Structural Steel Buildings.

B. American National Standards Institute (ANSI):
   1. B212-15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
   2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.

3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
4. D1.1 - Structural Welding Code - Steel.
5. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
1. A 6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
2. A 29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for.
3. A 36 - Standard Specification for Carbon Structural Steel.
4. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
5. A 108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
6. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
7. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
8. A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications.
9. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
10. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
11. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
12. A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
13. A 489 - Standard Specification for Carbon Steel Lifting Eyes.
14. A 490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
15. A 496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
16. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
17. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
18. A 992 - Standard Specification for Structural Steel Shapes.
19. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
20. F 959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
21. F 1554 – Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements.
2. AC58 - Acceptance Criteria for Adhesive Anchors in Masonry Elements.
3. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.
4. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

1.03 DEFINITIONS

A. Anchor bolt:
   1. Straight steel rod or bar embedded in concrete and having 1 headed end and 1 threaded end.
   2. Installed with headed end cast into concrete with embedment as indicated on the Drawings or specified, leaving threaded end projecting clear of concrete face as required for connection to be made.

1.04 SUBMITTALS

A. Quality control submittals:
   1. Submit shop drawings of members to be fabricated before starting their fabrication.
   2. Welder's certificates.

B. Test reports:
   1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
   2. Steel fabricators shall be certified by the AISC or other certification as recognized and accepted by the local building official having jurisdiction.
   3. Notify Engineer 24 hours minimum before starting shop or field welding.
   4. Engineer may check materials, equipment, and qualifications of welders.
   5. Remove welders performing unsatisfactory Work, or require to requalification.
   6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
   7. Contractor shall bear costs of retests on defective welds.
   8. Contractor shall also bear costs in connection with qualifying welders.
   9. Special inspection for the installation of chemical anchors as specified in Section 01455 is required.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified or Indicated on the Drawings, materials shall conform to the following:

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A 36	--
Rolled W and WT shapes	A 992	Grade 50
Hollow structural sections (HSS): Round, square, or rectangular	A 500	Grade B
Tubing, hot-formed	A 501	--
Round HSS	A 500	Grade B
Steel pipe	A 53	Grade B
Stainless Steel		
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

B. Where stainless steel is welded, use low-carbon stainless steel.

2.02 FASTENERS

A. General: Furnish threaded fasteners, except high strength bolts, with flat washers, and self-locking nuts, or lock washers and nuts.
   1. Bolt heads and nuts: Hex-type.
   2. Bolts, nuts, and washers: Of domestic manufacture.
   3. Where bolts, including anchor bolts, nuts, washers, and similar fasteners are specified to be galvanized, galvanize in accordance with ASTM A 153.

B. Anchor bolts:
   1. Forged steel bolt with straight shaft and integral heavy hex head.
      a. Rods or bars with angle bend for embedment into and anchoring in concrete are not allowed.
   2. Anchor bolts, nuts, and washers: Type 316 stainless steel in accordance with ASTM F 593 where indicated on the Drawings and for use in wet and moist locations, including:
      a. Water-containing structures:
         1) Below and at water level.
         2) Above water level:
            a) Below top of walls of water-containing structures.
            b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
         3) Dry side of walls of water-containing structures.
      b. Pump bases.
   3. Anchor bolts, nuts, and washers: Type 304 or Type 316 stainless steel for fastening aluminum to concrete or steel.

4. Anchor bolts, nuts, and washers: Hot-dip galvanized ASTM F 1554, Grade 36 for applications other than those specified.

C. Assembly bolts:
   1. Bolts, nuts, and washers for wood baffles, collectors, and other field-assembled construction: Type 316 stainless steel in accordance with ASTM F 593 where indicated on the Drawings and for use in wet and moist locations, including:
      a. Water-containing structures:
         1) Below and at water level.
         2) Above water level:
            a) Below top of walls of water-containing structures.
            b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
            c) Dry side of walls of water-containing structures.
      b. Pump bases.
   2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
   3. Hot-dip galvanized ASTM A 307 steel for galvanized assemblies and for applications other than those specified.

D. Concrete anchors:
   1. Concrete anchors for anchorage to concrete:
      a. Concrete anchors shall have current ICC-ES Report that demonstrates compliance with ICC-ES AC193 for cracked concrete.
      b. Manufacturers: One of the following or approved equal:
         1) Hilti Incorporated, Kwik Bolt TZ Expansion Anchor.
         2) Simpson Strong Tie, Strong Bolt Wedge Anchor.
   2. Concrete anchors for anchorage to masonry:
      a. Concrete anchors shall have current ICC-ES Report that demonstrates compliance with ICC-ES AC01.
      b. Manufacturers: One of the following or approved equal:
         1) Hilti Incorporated, Kwik Bolt 3 Expansion Anchor.
         2) Simpson Strong Tie, Wedge-All Anchor.
   3. Concrete anchor's integral threaded stud, wedge, washer, and nut: Type 304 or Type 316 stainless steel in accordance with ASTM F 593 where indicated on the Drawings and for use in wet and moist locations, including:
      a. Water-containing structures:
         1) Below and at water level.
         2) Above water level:
            a) Below top of walls of water-containing structures.
            b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
         3) Dry side of walls of water-containing structures.
      b. Pump bases.
   4. Concrete anchor's integral threaded stud, wedge, washer, and nut: Type 304 or 316 stainless steel in accordance with ASTM F 593 where indicated on the Drawings and for fastening aluminum to concrete or steel.
   5. Concrete anchor's integral threaded stud, wedge, washer, and nut: Hot-dip galvanized carbon steel, for applications other than those specified.
   6. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.

E. Concrete inserts: 1 piece, hot-dip galvanized, integrally hot forged unit fabricated from steel in accordance with ASTM A 29 Hot Rolled Grade 1045 requirement. Manufacturers: One of the following or approved equal:
   1. Dayton Superior, F-54 Ductile Embedded Insert.

F. Deformed bar anchors: In accordance with ASTM A 496:
   1. Manufacturers: One of the following or approved equal:
      a. Nelson Stud Welding Company, D2L Deformed Bar Anchors.
      b. Stud Welding Products, DBA (Deformed Bar) Anchors.

G. Eyebolts:
   1. Welded or forged, when manufactured of materials other than carbon steel.
   2. Having geometric and strength characteristics of eyebolts in accordance with ASTM A 489, Type 1. The strength characteristics include proof load requirements, breaking strength requirements, tensile strength requirements, bend test, and impact strength.

H. High strength bolts: High strength bolts, nuts, and hardened flat washers shall be in accordance with ASTM A 325 or ASTM A 490, as indicated on the Drawings.

2.03 ISOLATING SLEEVES AND WASHERS

A. Manufacturers: One of the following or approved equal:
   1. Central Plastics Company, Shawnee, Oklahoma.
   2. Corrosion Control Products, PSI Inc., Gardena, CA.

B. Sleeves: Mylar, 1/32 inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
   1. 1 sleeve required for each bolt.

C. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter.
   1. Proper size to fit bolts. Two insulating washers are required for each bolt.
   2. Two 1/8-inch thick steel washers for each bolt.
   3. G3 Phenolic:
      a. Thickness: 1/8 inch.
      b. Base material: Glass.
      c. Resin: Phenolic.
      d. Water absorption: 2 percent.
      e. Hardness (Rockwell): 100.
      f. Dielectric strength: 450 volts per mil.
      g. Compression strength: 50,000 pounds per square inch.
      h. Tensile strength: 20,000 pounds per square inch.
      i. Maximum operating temperature: 350 degrees Fahrenheit.

2.04 GALVANIZED SURFACE REPAIR

A. Manufacturers: One of the following or approved equal:
   1. Galvinox.
   2. Galvo-Weld.

2.05 THREAD COATING

A. Manufacturers: One of the following or approved equal:
   1. Never Seez Compound Corporation, Never-Seez.
   2. Oil Research, Inc., WLR No. 111.

2.06 SUPPLEMENTARY PARTS

A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.07 FABRICATION

A. Shop assembly:
   1. Fabricate structural steel in accordance with AISC "Specification for the Structural Steel Buildings - Allowable Stress Design and Plastic Design," unless otherwise specified or modified by applicable regulatory requirements.
   2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
   3. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
      a. Make full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as members indicated on the Drawings.
      b. Fabricate shapes using laser-fused full penetration joints. Fabricate shapes from dual grade stainless steel, fabricate beams and channels to ASTM A 6 tolerances.
         1) Manufacturers: The following, or equal:
            a) Stainless Structurals, LLC, Jacksonville, FL.
   4. Where galvanizing is required, hot-dip galvanize structural steel after fabrication in accordance with ASTM A 123:
      a. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
      b. Restraighten galvanized items that bend or twist during galvanizing.
   5. Round off sharp and hazardous projections and grind smooth.
   6. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
   7. Take responsibility for correct fitting of all metalwork.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

A. General:
   1. Fabricate structural and foundry items to true dimensions without warp or twist.
   2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
   3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
   4. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
   5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
   6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
   7. Erect structural steel in accordance with AISC "Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design," unless otherwise specified or modified by applicable regulatory requirements.
   8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
   9. Round off sharp or hazardous projections and grind smooth.
   10. Paint or coat steel items as specified in Section 09960.

B. Welding - General:
   1. Make welds full penetration type, unless otherwise indicated on the Drawings.
   2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

C. Welding stainless steel:
   1. General: Comply in accordance with AWS D1.6.

D. Welding carbon steel:
   1. General: Comply in accordance with AWS D1.1:
      a. Weld ASTM A 36 and A 992 structural steel, ASTM A 500 and A 501 structural tubing, and ASTM A 53 pipe with electrodes conforming in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
         1) Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

E. Interface with other products:
   1. Where steel fasteners come in contact with aluminum or other dissimilar metals, bolt with stainless steel bolts and separate or isolate from dissimilar metals with isolating sleeves and washers.
      a. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

F. Fasteners:
   1. General:
      a. Install bolts, including anchor bolts and concrete anchors, to project 2 threads minimum, but 1/2 inch maximum beyond nut.

b. For bolts identified as ASTM A 325 and A 490, see tightening requirements under “High Strength Bolts.”
c. Unless otherwise specified, tighten bolts, including anchor bolts and concrete anchors, to the "snug-tight" condition, defined as tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.

2. Anchor bolts:
   a. Cast-in-place when concrete is placed.
   b. Accurately locate anchor bolts embedded in concrete with bolts perpendicular to surface from which they project.
   c. Do not allow anchor bolts to touch reinforcing steel.
   d. Where anchor bolts are within 1/4 inch of reinforcing steel, isolate with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   e. In anchoring machinery bases subject to heavy vibration, use 2 nuts, with 1 serving as a locknut.
   f. Where bolts are indicated on the Drawings for future use, first coat thoroughly with nonoxidizing wax, then turn nuts down full depth of thread and neatly wrap exposed thread with waterproof polyvinyl tape.
   g. Furnish anchor bolts with standard hex bolt head or an equivalent head acceptable to Engineer unless otherwise indicated on the Drawings. “L” or “J” anchor bolts are not equivalent to an anchor bolt with a hex bolt head.
   h. Minimum anchor bolt embedment: 10-bolt diameters, unless longer embedment is indicated on the Drawings.
3. Concrete anchors:
   a. Do not use concrete anchors in lieu of anchor bolts.
   b. Install anchors in accordance with approved ICC-ES Report. Where conflict exists between the approved ICC-ES Report and the requirements in this Section, the requirements of the Evaluation Service Report shall control.
   c. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
   d. Minimum embedment lengths:

Diameter Inches	**Embedment Length Inches**
1/4	2
3/8	2-1/2
1/2	4-1/8
5/8	4-1/2
3/4	6-1/2

   e. Drilling holes:
      1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
      2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
      3) Remove dust and debris from hole using compressed air.
   f. Hole drilling equipment:
      1) Electric or pneumatic rotary type with light or medium impact.

2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
3) Hollow drills with flushing air systems are preferred.
4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

4. High strength bolts:
   a. Consider connections with high strength bolts to be slip critical structural connections, unless otherwise indicated on the Drawings.
   b. Connections with high strength bolts shall conform in accordance with AISC Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.
   c. Furnish hardened flat washer:
      1) Under element, nut, or bolt head, turned in tightening.
      2) On outer plies for short slotted holes.
   d. Verify adequate tightening of bolts by means of tension indicator washers placed as indicated in ASTM F 959, Figure 1.
5. Powder actuated fasteners: Use powder actuated fasteners only for applications indicated on the Drawings or specified.
6. Sleeve anchors:
   a. Do not use sleeve anchors in lieu of anchor bolts.
   b. Install anchors in accordance with approved ICC-ES Report. Where conflict exists between the approved ICC-ES Report and the requirements in this Section, the requirements of the Evaluation Service Report shall control.
   c. The sleeve anchor bolt shall be removable and the expansion sleeve shall be flush with the concrete surface when installed.
   d. Accurately locate sleeve anchors and set perpendicular to surfaces from which they project.
   e. Minimum embedment lengths:

Diameter millimeters (inches)	**Embedment Length millimeters (inches)**
12 (0.47)	80 (3-1/8)
16 (0.63)	105 (4-1/8)
20 (0.79)	130 (5-1/8)

   f. Drilling holes:
      1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
      2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
      3) Remove dust and debris from hole using compressed air.
   g. Hole drilling equipment:
      1) Electric or pneumatic rotary type with light or medium impact.
      2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
      3) Hollow drills with flushing air systems are preferred.
      4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

END OF SECTION

SECTION 05122

GALVANIZED STRUCTURAL STEEL FOR ALUMINUM RESERVOIR ROOF DECK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Galvanized structural steel support structure for aluminum reservoir roof decks.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 05120 - Structural Steel.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

1.03 SUBMITTALS

A. Shop drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural steel: In accordance with Section 05120.

B. Exposed fasteners: Stainless steel, minimum Number 14 size screws or 3/16-inch diameter rivets.

C. Bolts, nuts, washers, and anchor bolts: Type 316 stainless steel.

D. Locknuts: Type 316 stainless steel with nylon inserts.

E. Manufacturers: One of the following or equal:
   1. Aero Stop Nut Corporation, Newark, New Jersey.

F. Zinc touch-up paint:
   1. Manufacturers: One of the following or equal:
      a. Dry-galv.
      b. ZRC.

2.02 FABRICATION

A. Drill holes for aluminum deck clip fasteners.

B. Galvanize steel fabricated items after punching and drilling holes and attachment of welded parts to main members or components of detachable assemblies. Oversize holes before galvanizing to allow for free and easy insertion of bolts and components that are intended to have free motion to prevent forcing bolts or thimbles into galvanized holes.

C. Do not ream, scrape, or drill holes in field to receive thimbles, bolts, or pins.

D. Galvanize reservoir structural roof framing members, including girders, purlins, clip angles, and expansion joint components in accordance with ASTM A 123.

2.03 SOURCE QUALITY CONTROL

A. Engineer may select random structural components for making tests for proper coating thickness.

B. Hot-dip galvanize in DIP tanks free of contaminants and residue. Replace contaminated fluid with new fluid as soon as discolorations begin to appear on galvanized steel beams.

C. Remove components not meeting specified zinc quality and quantity from the site.

D. Regalvanize to meet Specification requirements.

E. Engineer may inspect DIP tank.

PART 3 EXECUTION

3.01 ERECTION

A. Install galvanized structural steel in accordance with Section 05120.

3.02 REPAIR

A. Clean cut, burned, or otherwise damaged galvanized surfaces of oil, dirt and corrosion. Coat with zinc touch up paint.

END OF SECTION

SECTION 05190

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
      b. Anchor rods.
      c. Concrete inserts.
   2. Post-installed steel anchors and fasteners
      a. Concrete anchors.
   3. Appurtenances for anchoring and fastening.
      a. Isolating sleeves and washers.
      b. Thread coating for threaded stainless steel fasteners.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittals.
      b. Section 01410 - Regulatory Requirements.
      c. Section 01450 - Quality Control.
      d. Section 01455 - Special Tests and Inspections.
      e. Section 01610 - Project Design Criteria.
      f. Section 03055 - Epoxy Bonding Reinforcing Bars and All Thread Rods In Concrete.
      g. Section 03600 - Grouting.
      h. Section 04055 - Epoxy Bonding Reinforcing Bars and All Thread Rods in Masonry.
      i. Section 05120 - Structural Steel.
      j. Section 05500 - Metal Fabrications.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 – Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.

B. American National Standards Institute (ANSI):
   1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.
   2. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A 108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   4. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   6. A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   7. A 194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   8. A 240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   9. A 308 - Standard Specification for Steel Sheet, Terne (Lead-Tin Alloy) Coated by the Hot-Dip Process.
   10. A 496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
   11. A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
   12. B 633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
   13. B 695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
   14. E 488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
   15. F 436 - Standard Specification for Hardened Steel Washers.
   16. F 1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
   1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 DEFINITIONS

A. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60-degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

E. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.

F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
    1. Corrosive locations: Describes interior and exterior locations as follows:
        a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
        b. Exterior and interior locations at the following treatment structures.
            1) Wastewater treatment facilities: Liquids stream:
                a) Raw wastewater delivery and holding structures.
                b) Headworks.
                c) Primary clarifiers and primary clarifier flow splitting boxes.
            2) Wastewater treatment facilities: Solids stream:
                a) Sludge holding and thickening tanks.
                b) Digesters.
                c) Dewatering facilities.
    2. Wet and moist locations: Describes locations, other than "corrosive locations," that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
        a. Exterior portions of buildings and structures.
        b. Liquid-containing structures:
            1) Locations at and below the maximum operating liquid surface elevation.
            2) Locations above the maximum operating liquid surface elevation and:
                a) Below the top of the walls containing the liquid.
                b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams or walkways enclosing the open top of the structure).
        c. Liquid handling equipment:
            1) Bases of pumps and other equipment that handles liquids.
        d. Indoor locations exposed to moisture, splashing or routine wash down during normal operations, including floors with slopes toward drains or gutters.
        e. Other locations indicated on the Drawings.

3. Other locations:
    a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 SUBMITTALS

A. General:
1. Submit as specified in Section 01330.
2. Submit information listed for each type of anchor or fastener to be used.

B. Action submittals:
1. Product data:
    a. Cast-in anchors.
        1) Manufacturer's data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
    b. Post-installed anchors.
        1) For each anchor type, manufacturer's data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings .
2. Samples:
    a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
3. Certificates:
    a. Cast-in anchors:
        1) Mill certificates for steel anchors that will be supplied to the site.
    b. Post-installed anchors:
        1) Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.
4. Test reports:
    a. Post-installed anchors: For each anchor type used for the Work:
        1) Current ICC-ES Report (ESR), or equivalent acceptable to the Engineer, demonstrating:
            a) Acceptance of that anchor for use under the building code specified in Section 01410.
5. Manufacturer's instructions.
    a. Requirements for storage and handling.
    b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
    c. Requirements for inspection or observation during installation.
6. Qualification statements.
    a. Post-installed anchors: Installer qualifications:
        1) Submit list of personnel performing installations and include date of manufacturer's training for each.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Post installed anchors shall be in accordance with building code specified in Section 01410.

B. Special inspection:
   1. Provide special inspection of post-installed anchors as specified in Section 01455 and this Section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.

B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.

C. Protect anchors from weather and moisture until installation.

1.07 PROJECT CONDITIONS

A. As specified in Section 01610.

B. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
      b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
         1) Rods or bars with angle bend for embedment in concrete (i.e.: “L” or “J” shaped anchor bolts) are not permitted in the Work.
   2. Materials:
      a. Type 316 stainless steel:
         1) Bolts: ASTM A 193, Grade B8M, Class 1, heavy hex.
         2) Nuts: ASTM A 194, Grade 8M, heavy hex.
         3) Washers: Type 316 stainless steel.
      b. Type 304 stainless steel:
         1) Bolts: ASTM A 193, Grade B8, Class 1, heavy hex.
         2) Nuts: ASTM A 194, Grade 8, heavy hex.
         3) Washers: Type 304 stainless steel.
      c. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM A 153.
         2) Bolt: ASTM F 1554, Grade 36, heavy hex.
         3) Nuts: ASTM A 563, Grade A, heavy hex.
         4) Washers: ASTM F 436.

B. Anchor rods:
   1. Description: Straight steel rod having threads on each end or continuously threaded from end to end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
   2. Materials:
      a. Stainless steel: Type 316:
         1) Rod: ASTM A 193, Grade B8M, Class 1.
         2) Nuts: ASTM A 194, Grade 8M.
         3) Washers: Type 316 stainless steel.
         4) Plates (embedded): ASTM A 240.
      b. Stainless steel: Type 304:
         1) Rod: ASTM A 193, Grade B8, Class 1.
         2) Nuts: ASTM A 194, Grade 8.
         3) Washers: Type 304 stainless steel.
         4) Plates (embedded): ASTM A 240.
      c. Galvanized: steel:
         1) Hot-dip galvanized with coating in accordance with ASTM A 153.
         2) Rod: ASTM F 1554, Grade 36.
         3) Nuts: ASTM A 563, Grade A.
         4) Washers: ASTM F 436.
         5) Plates (embedded): ASTM A 36.

C. Concrete insert: Ductile embed.
   1. Description: 1-piece, integrally hot forged sleeve for embedment in concrete. Provided with flange for nailing to forms and female threaded coupler at the exposed concrete face, and washer-faced hex headed foot to resist pullout from concrete at the embedded end.
   2. Manufacturers: The following or equal:
      a. Dayton Superior: F-54 Ductile Embed Insert.
   3. Materials:
      a. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM A 123 or A 153 where indicated on the Drawings.
         2) Steel: ASTM A 29 hot rolled, Grade 1045.

2.03 POST-INSTALLED ANCHORS AND FASTENERS – ADHESIVE

A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03055.

B. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in masonry: As specified in Section 04055.

2.04 POST-INSTALLED ANCHORS AND FASTENERS – MECHANICAL

A. General:
   1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01410.
      a. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
         1) In regions of concrete where cracking has occurred or may occur.
         2) To resist short-term loads due to wind forces.
         3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.
   2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
      a. Calculations shall be prepared by and shall bear the signature and sealed of a Civil or Structural Engineer licensed in the State of Arizona.
      b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.

2. Concrete anchors for anchorage to concrete:
    a. Acceptance criteria. Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    b. Manufacturers: One of the following or equal:
        1) Hilti: Kwik Bolt TZ Expansion Anchor.
        2) Powers fasteners: PowerStud+ SD2.
        3) Simpson Strong-Tie®: Strong Bolt 2 Wedge Anchor.
    c. Materials. Integrally threaded stud, wedge, washer and nut:
        1) Stainless steel: Type 316.
        2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B 633, minimum 5 microns (Fe/Zn 5).
3. Concrete anchors for anchorage to concrete masonry (fully grouted cells):
    a. Acceptance criteria: Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified in accordance with ICC-ES AC01, including all mandatory tests and optional seismic tests.
    b. Manufacturers: One of the following or equal:
        1) Hilti: Kwik Bolt 3 Expansion Anchor.
        2) Powers fasteners: Power-Stud+ SD1.
        3) Simpson Strongtie: Wedge-All Anchor.
    c. Materials. Integrally threaded stud, wedge, washer and nut:
        1) Stainless steel: Type 316.
            a) Type 304 stainless steel acceptable for use at wet and moist locations when accepted in writing by the Engineer.
        2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B 633, minimum 5 microns (Fe/Zn 5) or mechanically galvanized in accordance with ASTM B 695, Class 55, Type 1.

2.05 APPURTENANCES FOR ANCHORING AND FASTENING

A. Isolating sleeves and washers.
    1. Manufacturers: One of the following or equal:
        a. Central Plastics Company, Shawnee, Oklahoma.
        b. Corrosion Control Products, PSI Inc., Gardena, CA.
    2. Sleeves: Mylar, 1/32 inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
    3. One sleeve required for each bolt.
    4. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter.
        a. Proper size to fit bolts. 2 insulating washers are required for each bolt.
        b. Two 1/8-inch thick steel washers for each bolt.
        c. G3 Phenolic:
            1) Thickness: 1/8 inch.
            2) Base material: Glass.
            3) Resin: Phenolic.
            4) Water absorption: 2 percent.

5) Hardness (Rockwell): 100.
6) Dielectric strength: 450 volts per mil.
7) Compression strength: 50,000 pounds per square inch.
8) Tensile strength: 20,000 pounds per square inch.
9) Maximum operating temperature: 350 degrees Fahrenheit.

B. Coating for repair of galvanized surfaces.
1. Manufacturers: One of the following or approved equal:
a. Galvinox.
b. Galvo-Weld.

C. Thread coating. For use with threaded stainless steel fasteners.
1. Manufacturers: One of the following or equal:
a. Never Seez Compound Corporation, Never-Seez.
b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION: GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types.
1. Post-installed anchors may not be used as an alternative to cast-in / built-in anchors at locations where the latter are indicated on the Drawings.
2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Take special care to protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners.
1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

E. Interface with other products:
1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), bolt with stainless steel bolts and separate or isolate dissimilar metals using isolating sleeves and washers.
2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION: CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors.
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
      d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
   3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:
   1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
   2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Fill sleeves with grout when a machine or other equipment is grouted in place.

C. Anchor rods.
   1. Install as specified for anchor bolts.

D. Concrete inserts.
   1. Provide inserts with minimum clear concrete cover not less than that specified for reinforcing bars.

3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS.

A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03055.

B. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in masonry: As specified in Section 04055.

3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS.

A. General:
   1. Install anchors in accordance with the manufacturer’s instructions, ACI 355.2, the anchor’s ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.

2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
3. After anchors have been positioned and inserted into concrete or masonry, do not:
    a. Remove and reuse/reinstall anchors.
    b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry.
1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'c or f'm).
2. Accurately locate holes.
    a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
    b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
    a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
5. Drill using anchor manufacturer's recommended equipment and procedures.
    a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
        1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
        2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
6. Drill holes at manufacture's recommended diameter and to depth required to provide the effective embedment indicated.
7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
    a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
    b. Repeat cleaning process as required by the manufacturer's installation instructions.
    c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions.
1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum required member thickness
	In concrete	In grouted masonry	
3/8 inch	2 1/2 inch	2 5/8 inch	8 inch
1/2 inch	3 1/2 inch	3 1/2 inch	8 inch
5/8 inch	4 1/2 inch	4 1/2 inch	10 inch
3/4 inch	5 inch	5 1/4 inch	12 inch

3.06 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.

B. Post-installed anchors:
   1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
   3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

3.07 FIELD QUALITY ASSURANCE

A. Owner's Representative will provide on-site observation and field quality assurance for the Work of this Section.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.
   2. Record of inspections:
      a. Maintain record of each inspection.
      b. Submit copies to Engineer upon request.
   3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry.
   1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
      a. Anchor bolts.

b. Anchor rods.
c. Concrete inserts (all types).

2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
   a. Anchor:
      1) Type and dimensions.
      2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
      3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
      4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
   a. Base material (concrete or grouted masonry):
      1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
      2) Material encapsulating embedment is dense and well-consolidated.

D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
   1. Provide special inspection during installation of the following anchors:
      a. Concrete anchors.
      b. Any post-installed anchors.
   2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
      a. Provide continuous special inspection for post-installed anchors in “overhead installations” as defined in this Section.
   3. Requirements for periodic special inspection:
      a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
         1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor, shall require a new “initial inspection.”
      b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor’s rated strength.
      c. Anchor:
         1) Manufacturer, type, and dimensions (diameter and length).
         2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
      d. Hole:
         1) Positioning: Spacing and edge distances.
         2) Drill bit type and diameter.
         3) Diameter, and depth.

4) Hole cleaned in accordance with manufacturer's required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
5) Anchor's minimum effective embedment.
6) Anchor tightening/installation torque.

4. Requirements for continuous special inspection:
   a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
1. Engineer may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
   a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
   b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.

3.08 NON-CONFORMING WORK.

A. Remove miss-aligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations as specified in Section 03600 using high-strength, non-shrink, non-metallic grout.

C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the Owner.

3.09 SCHEDULES

A. Stainless steel. Provide and install stainless steel anchors at the following locations.
1. "Corrosive locations" as defined in this Section: Type 316 stainless steel
2. "Wet and moist locations" as defined in this Section: Type 316 stainless steel.

B. Galvanized: Provide and install galvanized carbon steel anchors at the following locations:
1. Locations not requiring stainless steel.
2. At locations indicated on the Drawings.

C. Provide and install anchor materials as scheduled in the following Table.

Table – Required Anchoring Materials by Location.		
Location / Exposure	**Materials**	**Notes**
1. Anchors into concrete and grouted masonry for attachment of carbon steel, including structural steel and other steel fabrications:		
a. Interior dry areas:	Carbon steel – galvanized.	
b. Locations with galvanized steel structures or fabrications:	Stainless steel – Type 304 or 316.	1
c. Exterior and interior wet and moist locations:	Stainless steel – Type 316	1
d. Corrosive locations:	Stainless steel – Type 316	1
2. Anchors into concrete and grouted masonry for attachment of aluminum, stainless steel, or fiber-reinforced plastic (FRP) shapes and fabrications.		
a. Interior dry areas:	Stainless steel – Type 304 or 316.	1
b. Exterior and interior wet and moist locations:	Stainless steel – Type 316.	1
c. Corrosive locations:	Stainless steel – Type 316.	1
3. Anchors for attaching equipment and its appurtenances		
a. All locations	Stainless steel – Type 316 (unless Type 304 is specifically indicated in the specifications for the equipment.)	1
Notes: 1. Where anchors are in contact with a metal that differs from that of the anchor, provide isolation sleeves and washers.		

END OF SECTION

SECTION 05310

STEEL DECK

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Steel deck for floors and roofs, and associated accessories.

1.02 REFERENCES

A. American Welding Society (AWS):
   1. D1.3 - Structural Welding Code - Sheet Steel.

B. ASTM International (ASTM):
   1. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

1.03 SUBMITTALS

A. Product data, including deck structural properties.

B. Shop Drawings, including deck coating and connecting welds.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection:
   1. Store steel deck at the site stacked on platforms or pallets and covered with tarpaulins or other suitable weather tight covering.
   2. Do not use steel deck for storage or working platform.
   3. Remove damaged, unlabeled, untagged, rusty, and deteriorated steel deck material from the job site.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. ASC Profiles (Formerly IMSA Building Products).
   2. Verco Manufacturing Company.

2.02 MATERIALS

A. Sheet Steel: ASTM A 653, Galvanized G 90 minimum coating designation within the membrane treatment building and galvanized G60 minimum coating elsewhere.

2.03 FABRICATION

A. Steel deck shall be formed:
   1. So every sheet is identical and will register perfectly with adjacent sheets.
   2. In accordance with building code as specified in Section 01410.

B. Furnish minimum gauge, deck thickness, section modulus, moment of inertia, and allowable diaphragm shear per foot of deck width that is not less than for type deck sections indicated on the Drawings. Treat exposed roof deck with phosphate or other surface preparation in anticipation of field coating. “Exposed” refers to the underside of all roof deck that is not exposed to view on the underside by suspended ceiling.

C. Furnish roof deck ready to receive field painting without further pretreatment. Paint exposed roof deck in accordance with the Specifications.

D. Accessories:
   1. Furnish all accessories indicated on the Drawings or needed to completed work.
   2. Minimum Required Gauges:
      a. Sump Pans: 14 gauge galvanized steel.
      b. All other accessories: 20 gauge galvanized steel unless otherwise indicated on the Drawings.

E. Welding and Electrodes: In accordance with AWS D1.3.

F. Furnish roof decking in lengths to minimize number of splices.

G. Furnish steel deck complete, including cutting, shaping, fitting, drilling, welding, ridge plates, valley plates, reinforcing plates for openings, and miscellaneous pieces necessary for proper installation. Where steel beams are shown at the marginal edges of deck panels, fabricate deck “make-up” sections, if required, to ensure that deck vertical support is provided at the edge, and deck sections are joined as required to maintain diaphragm shear transfer to edge supports.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

B. Where decks are to be supported by masonry walls, ensure the walls are at the correct elevation.

3.02 INSTALLATION

A. Decking shall span over at least 3 spans wherever possible, but a minimum of 2 spans. Where 2 spans are necessary, the deck shall be placed in the center one-third of the roof width.

B. Do not damage or overload roof deck during installation.

C. Do not use steel deck for storage or as a working platform until sheets have been welded in position.

D. Do not exceed maximum uniformly distributed load of 20 pounds per square foot during installation.

E. Install decking in straight and continuous rows as far as practicable, with ribs at right angles to supporting members.

F. For each end of deck section, provide 3 inches minimum bearing on supports. At deck splices weld both deck sections to support by overlapping.

G. Electric arc weld deck sections to bearing plates, supports at butt joints, at intermediate supports, side supports, and at end supports as indicated on the Drawings. Do not burn through the deck. Remove all slag.

H. Fasten the longitudinal joints between deck sections together by the method indicated on the Drawings.

I. Neatly cut and fit openings in roof deck, and reinforce with structural steel members as indicated on the Drawings.

J. Paint welds as specified.

K. Install roof deck free of dents and bent members.

L. Reinforce all holes and openings in steel deck as indicated on the Drawings.

M. Piping, conduit, equipment, and other services: Do not hang from decking.

N. Install all accessories required to complete work.

O. Suspended Items:
   1. Ductwork:
      a. Do not attach hangers to deck within the center 1/3 of span.
      b. Only 1 hanger may be attached to any 1 rib within 1 span.
      c. Attach wire hangers to decking with clips through hanger tabs.

3.03 REPAIR OF GALVANIZING AND COATING

A. Touch-up damage to galvanized surfaces, including cut edges and holes, with zinc rich primer.

B. Repair damage to factory-applied coating system in accordance with the manufacturer's printed recommendations.

3.04 CLEANUP

A. After erection, remove weld spatter, grease, and oil from decking.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Aluminum grating stair tread.
   2. Aluminum stair nosing.
   3. Concrete inserts.
   4. Handrails and guardrails.
   5. Ladders.
   6. Manhole steps.
   7. Metal gratings.
   8. Metal tread plate.
   9. Preformed channel pipe supports.
   10. Stairs.
   11. Miscellaneous metals.
   12. Associated accessories to the above items.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. Specification M12-C22-A41 - Aluminum Finishes.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

C. American Welding Society (AWS):
   1. Standard Symbols for Welding, Brazing, and Nondestructive Examination.

D. ASTM International (ASTM):
   1. A 36/A 36M - Standard Specification for Structural Steel.
   2. A 48 - Standard Specification for Grey Iron Castings.
   3. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   4. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A 240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
   6. A 269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   7. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
   8. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   9. A 325 - Standard Specification for High-Strength Bolts for Structural Steel Joints.
   10. A 489 - Standard Specification for Carbon Steel Lifting Eyes.

11. A 490 - Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength.
12. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
13. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
14. A 569 - Standard Specification for Steel, Carbon (0.15 Maximum, Percent) Hot-Rolled Sheet and Strip Commercial Quality.
15. A 570/A 570M - Standard Specification for Steel, Sheet and Strip, Carbon. Hot-Rolled, Structural Quality.
16. A 635/A 635M - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled.
17. A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
18. A 992/A 992M - Standard Specification for Structural Steel Shapes.
19. B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
20. B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
21. B 308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
22. B 429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.

E. National Association of Architectural Metal Manufacturers (NAAMM):
1. Metal Finishes Manual.

F. Occupational Safety and Health Administration (OSHA).
1. Code of Federal Regulations (CFR), Title 29, Labor, Pt. 1900-1990.

1.03 SUBMITTALS

A. Product Data:
1. Aluminum grating stair tread.
2. Aluminum stair nosing.
3. Handrail and Guardrail
4. Manhole frames and covers.
5. Metal grating.
6. Covered aluminum grating.
7. Stairs.

B. Shop Drawings:
1. Handrails and Guardrails:
   a. Including details on connection attachments, gates, kickplates, ladders, and angles.
   b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
   c. Include erection drawings, elevations, and details where applicable.
   d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
2. Ladders.

3. Metal grating.
4. Metal tread plate.
5. Stairs.
6. Miscellaneous metals.
7. Submittals shall be on size 30-inch x 42-inch drawings.

C. Samples:
1. Guardrails with specified finishes.

D. Quality Control Submittals:
1. Design data.
2. Test Reports:
a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and Occupational Safety and Health Administration strength requirements.
b. Gratings:
1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
2) Reports of tests performed.
c. Planks:
1) Plank manufacturers' calculations showing that planks will meet specified load-bearing and deflection requirements for each size plank for each span.
2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals shall conform with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Cast Iron		
Cast Iron	A 48	Class 40B
Steel		
Galvanized sheet iron or steel	A 653	Coating G90
Black steel, sheet or strip	A 569 A 570	--
Coil (plate)	A 635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A 36	--
Rolled W shapes	A 992	Grade 50
Standard bolts, nuts, and washers	A 307	--

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
High strength bolts, nuts, and hardened flat washers	A 325 A 490	--
Eyebolts	A 489	Type 1
Tubing, cold-formed	A 500	--
Tubing, hot-formed	A 501	--
Steel pipe	A 53	Grade B
Stainless steel		
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
Aluminum		
Flashing sheet aluminum	B 209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B 209	Alloy 6061-T6
Structural aluminum	B 209 B 308	Alloy 6061-T6
Extruded aluminum	B 221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

A. Aluminum Grating Stair Tread:
   1. Manufacturers: One of the following or equal:
      a. IKG Borden Industries, Aluminum Grating Stair Tread with Mebac nosing.
      b. McNichols Co., Type A-Standard with Corrugated Angle Nosing.
   2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers.
   3. Design: Must be in compliance with IBC 2006. Typical Details in Contract Drawings represent minimum requirements.
   4. Size:
      a. Tread Width: To equal tread spacing plus 1 inch minimum.
      b. Tread Length: Length to suit stringer to stringer dimension indicated on the Drawings.
      c. Depth: 1-3/4 inches.
   5. Bolts: Type 316 stainless steel.

B. Aluminum Stair Nosing:
   1. Manufacturers: One of the following or equal:
      a. Wooster Products, Inc., Type 101 Nosing.
      b. American Safety Tread Co., Inc., Style 801 Nosing.

2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
3. For installation in cast-in-place stairs.
4. Configuration: Four inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.

C. Concrete Inserts:
1. Concrete inserts for supporting pipe and other applications are specified in Section 15061.

D. Handrails and Guardrails:
1. General: Typical Details shown on the Drawings represent minimum requirements. Design and fabricate assemblies to conform to current local, State, and Occupational Safety and Health Administration standards and requirements.
2. Aluminum Handrails and Guardrails (Nonwelded Pipe):
a. Rails, Posts, and Fitting-Assembly Spacers:
1) In accordance with ASTM B 429, 6063-T5 or T6, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
2) Alloy 6063-T6 may be used for pieces requiring bending only.
b. Kick Plates: 6061-T6 aluminum alloy.
c. Fastenings and Fasteners: As recommended or furnished by the manufacturer.
d. Other Parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
1) Fabrications: In accordance with ASTM B 209 or ASTM B 221 extruded bars:
a Bases: 6061 or 6063 extruded aluminum alloy.
2) Plug Screws or Blind Rivets: Type 305 stainless steel.
b Other Parts: Type 300 series stainless steel.
e. Finish of Aluminum Components:
1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish-medium satin, chemical finish-medium matte, anodic coating-clear Class I Architectural.
2) Pretreat aluminum for cleaning and removing markings before anodizing.
f. Fabrication and Assembly:
1) Fabricate posts in single, unspliced pipe length.
2) Perform without welding.
3) Do not epoxy bond the parts.
4) Maximum clear opening between assembled railing components as indicated on the Drawings.
g. Manufacturers: One of the following or equal:
1) Moultrie Manufacturing Company, Wesrail.
2) Julius Blum and Company, Inc., Connectorail.
3) Craneveyor Corporation Enerco Metals, C-V Rail.
3. Steel Pipe Handrails and Guardrails:
a. Schedule 40 black steel pipe with minimum 1.9-inch outside diameter, or larger where indicated on the Drawings.

b. Fabricate posts in single, unspliced pipe length.
c. Kick Plates: Galvanized steel.
d. Attachment Devices: Provide clip angles and other fasteners necessary for securing handrails and guardrails to other construction as indicated on the Drawings.
e. Continuously weld joints and grind smooth.
f. Bend rails to profile indicated on the Drawings, without sharp bends or flat spots. Rails shall be round after bending.
g. Neatly weld intersection of rails and posts, and grind surfaces smooth.

4. Stainless Steel Pipe Handrails and Guardrails:
   a. Manufacturers: One of the following or equal:
      1) R & B Wagner, Inc.
      2) Julius Blum and Company.
   b. General: Prefabricated shop-assembled type, field welded type, or mechanically joined type.
   c. Materials: Type 304 or Type 316 stainless steel posts, rails, brackets, and accessory parts:
      1) Railings and Posts: Nominal 1-1/2-inch, Schedule 5 pipe with minimum 1.90-inch outer diameter and 0.065-inch wall thickness.
      2) Post Insert Reinforcing for All Posts: 1.750-inch outside diameter pipe, of 0.083-inch wall thickness, and 26 inches long.
      3) Fasteners, Connection Plates, Splice Bars, and Fittings: Type 304 or Type 316 stainless steel.
      4) Stainless Steel Finish: Number 4 satin finish in accordance with NAAMM Metal Finishes Manual.
   d. Fabrication:
      1) Fabricate guardrails and posts to be in same plane.
      2) Fabricate posts in single, unspliced pipe length.
      3) Make handrail and guardrail sections with 20 feet maximum between splices.
      4) Form bends in pipe without use of fittings where practical. Form with internal mandrels on power benders.
      5) Where handrail and guardrail are welded, make intersections and joints with continuous 360-degree welds and grind welds smooth.
5. Where handrail and guardrail are mechanically joined, make joints with mechanical connections utilizing stainless steel machine screws with lock washers and threaded tubular rivets.
6. Guardrail Gates:
   a. Supplied by Guardrail Manufacturer:
      1) Of same material, quality, and workmanship as specified for guardrail system in which they will be installed.
      2) Of design similar to that of handrail or railing system in which they will be installed.
   b. Components: Gate frame, stainless steel self-closing device, hinges, gate stops, and durable self-locking type latch. Fabricate components in conformance with Occupational Safety and Health Administration minimum strength requirements.
7. Fastenings and Fasteners: As recommended or furnished by guardrail manufacturer for use with this system.

E. Ladders:
   1. General:
      a. Type: Safety type conforming to local, State, and Occupational Safety and Health Administration standards as minimum. Furnish guards for ladder wells.
      b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
   2. Aluminum Ladders:
      a. Materials: 6063-T5 aluminum alloy.
      b. Rungs:
         1) One-inch minimum solid square bar with abrasive “slip-not” top surface.
         2) Capable of withstanding 1,000-pound load without failure.
      c. Side Rails: Minimum 4-inch by 1/2-inch flat bars.
      d. Fabrication:
         1) Welded construction, of size, shape, location, and details indicated on the Drawings.
         2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and Occupational Safety and Health Administration requirements.
      e. Fall Prevention System: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying Occupational Safety and Health Administration safe climbing requirements:
         1) Manufacturers: One of the following or equal:
            c North Consumer Products, Saf-T-Climb.
            d Swager Communications, Climbers Buddy System.

F. Manhole Frames and Covers:
   1. Material: Gray iron castings, in accordance with ASTM A 48, Class 30-B.
   2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
   3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
   4. Frame:
      a. Bottom flange type.
      b. Approximately 4-1/2 inches frame height.
      c. 24 inches diameter clear inside dimension and approximately 32 inches bottom flange outside diameter, unless otherwise indicated on the Drawings.
   5. Cover:
      a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as "ELECTRICAL," "SEWER," "TELEPHONE," or "WATER."
      b. Solid type without ventilation holes.
   6. Finish: Unpainted.

G. Manhole Steps:
   1. Type 316 stainless steel, of size, shape, and spacing indicated on the Drawings.

H. Metal Gratings:
   1. General:
      a. Fabricate grating to cover areas indicated on the Drawings.
      b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
      c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
      d. Band ends of grating and edges of cutouts in grating:
         1) End Banding: 1/4-inch less than height of grating, with top of grating and top edge of banding flush.
         2) Cutout Banding: Full-height of grating.
         3) Use banding of same material as grating.
         4) Panel Layout: Enable installation and subsequent removal of grating around protrusions or piping.
         5) Openings 6 Inches and Larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
         6) Openings smaller than 6 inches: Locate opening at edge of single panel.
         7) Fasten each grating section at corners and at maximum spacing of 2-ft., 6-in. cc each side. Where an area requires more than 1 grating section to cover an area, clamp adjacent grating sections together at maximum spacing of 2-ft., 6-in. cc with 2 fasteners acceptable to ENGINEER.
         8) Fabricate aluminum grating in units of maximum 80 pounds each. Fabricate steel grating in unit sizes shown on Drawings.
      e. When requested by ENGINEER, test 1 section of each size grating for each span length involved on the job under full load:
         1) Furnish a suitable dial gauge for measuring deflections.
      f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.
   2. Aluminum Grating:
      a. Material for Gratings, Shelf Angles, and Rebates: 6061-T6 or 6063-T6 aluminum alloy, except cross bars may be 6063-T5 aluminum alloy.
      b. Shelf Angle Concrete Anchors: Type 304 or Type 316 stainless steel.
      c. Grating Rebate Rod Anchors: 6061-T6 or 6063-T6 aluminum alloy.
      d. Bar Size and Spacing: As determined by manufacturer to enable grating to support design load.
      e. Design Live Load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
      f. Maximum Fiber Stress for Design Load: 12,000 pounds per square inch.
      g. Maximum Deflection Due to Design Load: 1/240 of grating clear span.
      h. Maximum Spacing of Main Grating Bars: 1-1/8 inches clear between bars.
      i. Minimum Grating Height: 1-1/2 inches.
      j. Manufacturers: One of the following or equal:
         1) IKG Borden Industries, grooved Galok Aluminum I-Bar.
         2) Seidelhuber Metal Products, Inc., grooved I-Bar.
   3. Aluminum Grating with Welded Cover Plate:
      a. Materials: Meet requirements previously specified for aluminum grating.
      b. Fabrication:
         1) Meet requirements previously specified for aluminum grating.

2) Shop weld 1/4-inch thick aluminum cover top plate.
3) Shop weld top plate continuous to provide air-tight unit.

c. Have unpunched surface with raised pattern anti-skid surface.
d. Minimum design load = 100 PSF.
e. Provide 1-inch diameter hole with smooth edges at each end for each covered grating..
f. Furnish covered grating in 3-foot widths.
g. Manufacturers: One of the following or equal:
1) Barnett Bates, Joliet, IL.
2) McNichols, Dallas, TX.

4. Steel Gratings:
a. Hot-dip galvanized in accordance with ASTM A 123.
b. Bar Size and Spacing: As determined by the manufacturer to support design load.
c. Design Live Load: A minimum of 100 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
d. Maximum Fiber Stress for Design Load: 18,000 pounds per square inch.
e. Maximum Deflection Under Design Load: 1/240 of grating clear span.
f. Bar Spacing: Maximum of 1-1/8 inches clear between bars.
g. Manufacturers: One of the following or equal:
1) IKG Borden Industries, IKG Weldforged.
2) Seidelhuber Metal Products, Inc., Type 19W4.

5. Heavy-Duty Steel Grating:
a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
b. Hot-dip galvanized after fabrication in accordance with ASTM A 123.
c. Manufacturers: One of the following or equal:
1) Reliance Steel Products Company, Heavy-Duty Steel Grating.
2) Seidelhuber Metal Products, Inc., equivalent product.

I. Preformed Channel Pipe Supports:
1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 15062.

J. Stairs:
1. Aluminum Stairs:
a. Stringers: 6061-T6 aluminum alloy.
b. Stair Treads:
1) Aluminum of same type specified under Aluminum Grating.
2) Of sizes indicated on the Drawings, and 1-3/4-inch minimum depth with cast abrasive type safety nosings.
c. Handrails and Guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Nonwelded Pipe).
d. Fasteners: Type 304 or Type 316 stainless steel.

K. Miscellaneous Metal:
1. Miscellaneous Aluminum: Fabricate aluminum products, not covered separately herein, in accordance with the best practices of the trade and field assemble by riveting or bolting. Do not weld or flame cut.

2. Miscellaneous Cast Iron:
    a. General:
        1) Tough, gray iron, free from cracks, holes, swells, and cold shuts.
        2) Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
        3) Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.
3. Miscellaneous Stainless Steel:
    a. Provide miscellaneous stainless steel items not specified herein as indicated on the Drawings or specified elsewhere. Fabricate and install in accordance with the best practices of the trade.
4. Miscellaneous Structural Steel:
    a. Provide miscellaneous steel items not specified herein as indicated on the Drawings or specified elsewhere. Fabricate and install in accordance with the best practices of the trade.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

A. General: Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.

B. Aluminum Stair Nosing:
    1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
    2. Omit stair nosings where concrete is submerged.
    3. Coat aluminum surfaces in contact with concrete as specified in Section 09960.
    4. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step approximately 3 inches from each stair edge.

C. Handrails and Guardrails:
    1. General:
        a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
        b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
        c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
        d. Space attachment brackets as indicated in the manufacturer's instructions.

2. Aluminum Pipe Handrails and Guardrails:
    a. During construction, keep exterior surfaces of handrails and guardrails covered with 0.4 millimeters, minimum, heat shrink polyethylene film.
    b. Do not remove protective film before handrails and guardrails have been accepted by ENGINEER nor before other work in proximity of handrails and guardrails has been completed.
    c. Discontinue handrails and guardrails at lighting fixtures.
    d. Provide 1/8-inch diameter weep hole at base of each post.
    e. Where protection is applied for prevention of dissimilar materials electrolysis, make application such that none of the protective material is visible in the completed assembly.
    f. Space posts as indicated on the Drawings.
    g. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
    h. Space rails as indicated on the Drawings.
    i. Make adequate provision for expansion and contraction of kickplates and rails. Make provisions for removable sections where indicated on the Drawings.
    j. Make lower rails a single, unspliced length between posts, or continuous.
    k. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
    l. Draw up fasteners tight with hand wrench or screw driver.
    m. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
    n. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
    o. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
    p. Replace damaged or disfigured handrails and guardrails with new.
    q. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water. After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
    r. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.
3. Steel Pipe Handrail and Guardrail:
    a. Anchor posts into concrete by grouting posts into galvanized steel sleeves embedded in concrete as indicated on the Drawings. Do not cut reinforcing bars in concrete. Where required to fasten guardrail to other construction, fasten as indicated on the Drawings.
4. Guardrail Gates:
    a. Install gate to be a vertical plane with the guardrail when in the closed position.
    b. Install hinges so that each gate can swing 180 degrees from the closed position to the fully open position.
    c. Install so that the gates swing to the walkway side of the guardrail only. Install gate stops on the stationary railing posts to prohibit gates from swinging in the wrong direction.

d. Install gate frames, hinges, stops, and latches in conformance with Occupational Safety and Health Administration minimum strength requirements.
e. Install inward opening gates where access is required to ladders, gate operators, cranes, or other mechanical equipment shown on mechanical drawings.

D. Ladders:
1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
4. Erect rail straight, level, plumb, and true to position indicated on the Drawings. Correct deviations from true line or grade which are visible to the eye.

E. Manhole Frames and Covers:
1. Installation: As specified in Section 02084.

F. Metal Gratings:
1. General:
a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
d. Install angle stops at ends of grating.
e. Installed grating shall not slide out of rebate or off support.
f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
2. Aluminum Grating:
a. Coat surfaces of aluminum shelf angles, rebates, and rod anchors in contact with concrete as specified in Section 09960.
b. Aluminum Grating: Support on aluminum shelf angles or rebates.
3. Aluminum Covered Grating:
a. Support and install covered grating as specified for aluminum grating.
b. Anchor each covered grating unit to aluminum support beams with stainless steel fasteners, at least 2 per support.
c. Field locate and drill holes for fasteners so that gaps between covered grating units do not exceed 1/16-inch.
4. Steel Grating:
a. Support on hot-dip galvanized structural steel shelf angles or rebates.
5. Heavy-Duty Steel Grating:
a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
b. Use for roadways, traffic areas, and where indicated on the Drawings.

G. Stairs:
    1. General:
        a. Install guard railings around stair wells as indicated on the Drawings or specified.

END OF SECTION

SECTION 06611

FIBERGLASS REINFORCED PLASTIC FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fiberglass reinforced plastic fabrications including:
   1. Weirs and baffles.
   2. Grating.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01600 - Product Requirements.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 01614 - Wind Design Criteria.
      d. Section 05120 - Structural Steel.

1.02 REFERENCES

A. NSF International (NSF):
   1. 61 - Drinking Water System Components-Health Effects.

PART 2 PRODUCTS

2.01 WEIRS, BAFFLES, AND STOP PLATES

A. Manufacturers: One of the following or equal:
   1. F. B. Leopold Company.
   2. Warminster Fiberglass Company.

B. Materials:
   1. Hand lay-up construction.
   2. Minimum corrosion liner:
      a. One "C" or Nexus veil as specified for the service environment.
      b. Remainder 1-1/2 ounce per square foot mat to total minimum thickness of 0.096 inches on surface exposed to the service environment.
   3. Ultraviolet stabilizer: Added to the exterior surface coat of fabrications intended for outside service, in the type and amount recommended by the resin manufacturer.

4. Resin: Premium grade vinyl ester:
    a. Manufacturers: One of the following or equal: As recommended by the resin manufacturer for the specific operating environment:
        1) Dow Chemical Company, Derakane 411.
        2) Ashland Chemical Company, Hetron 922.
        3) Reichhold Inc., Reichhold Dion VER 9100.
        4) Interplastic Corporation, Interplastic VE 8300.
5. Color: Natural, unless otherwise specified.

C. Fabrication:
1. Weirs:
    a. Match die molded.
    b. Weir plates:
        1) Of shape and dimensions specified.
        2) Provide 2-3/8 inch diameter holes for adjustment.
        3) Resin coat cut edges, and drilled and countersunk holes in fiberglass reinforced plastic fabrications.
    c. Furnish fiberglass reinforced plastic butt plates for joints.
    d. Washers:
        1) Of same material as weirs, with surfaces smooth, free of voids, and without dry spots and crazes.
        2) Design criteria and chemical exposure: As specified for the application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that conditions are satisfactory for installation of products as specified in Section 01600.

3.02 ERECTION AND INSTALLATION, GENERAL

A. Install products where indicated on the Drawings in accordance with manufacturer's printed instructions.

3.03 WEIR PLATES

A. Fasten to concrete with stainless steel anchor bolts or concrete anchors.

B. Seal edge between concrete and weir with synthetic rubber.

C. Use stainless steel washers under nuts.

END OF SECTION

SECTION 07190

WATER REPELLENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Water repellent for concrete masonry.

1.02 DEFINITIONS

A. Water repellent: Resistance to penetration of water from rainfall.

1.03 REFERENCES

A. International Union of Testing and Research Laboratories for Materials and Structures (RILEM):
   1. RILEM Test Method No. 11.4, Measurement Of Water Absorption Under Low Pressure

1.04 SYSTEM DESCRIPTION

A. Performance requirements: Surfaces with water repellent shall be uniform in color with unaltered texture.

1.05 SUBMITTALS

A. Product Data.

B. Samples: Water repellent applied on 8-inch by 8-inch substrates to receive water repellent, marked with application date and application rate.

C. Manufacturer's Application Instructions.

1.06 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of water repellents for minimum 5 years with satisfactory performance record.

B. Applicator qualifications: Trained, approved, and accepted by water repellent manufacturer.

C. Spray personnel qualifications: Minimum 2 years of experience spraying exotic coatings.

D. Regulatory requirements: Comply with volatile organic compound regulations.

E. Mock-ups:
   1. Apply water repellent on 8-foot by 8-foot mock-up walls. Use same equipment and procedures that will be used in applying material on walls.

2. Test mock-up for water penetration 30 days after applying water repellent in accordance with field quality control.
3. When accepted by the Engineer, mock-up walls will be standard for walls.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to site in manufacturer's original containers with seals unbroken and labeled with manufacturer's batch number.

B. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Apply water repellent under temperature and relative humidity conditions before, during, and after application in accordance with manufacturer's instructions.

B. Allow surfaces to dry for minimum 5 days after rains.

1.09 PROJECT CONDITIONS

A. Make proper material allowance based upon substrate material and surface configuration when determining quantities of material.

1.10 WARRANTY

A. Warrant to furnish and apply water repellent on walls that experience water penetration because of failure of water repellent for minimum **5** years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Water repellent sealer:
1. Manufacturers: One of the following or equal:
   a. Rainguard Products, Corona del Mar, CA.
   b. ProSoCo, Inc., Kansas City, KS.

2.02 MATERIALS

A. Water repellent sealer for concrete and concrete masonry: Silane/Siloxane; Volatile Organic Compound compliant; free of silicone oils, paraffin wax, or urethanes.
1. Manufacturers: One of the following or equal:
   a. Rainguard Products, Corona del Mar, CA, BLOK-LOK.
   b. ProSoCo, Inc., Kansas City, MO, Weather Seal Siloxane WB Concentrate.

2.03 EQUIPMENT

A. Spray equipment: High-volume, low-pressure, airless, with maximum 60 pounds per square inch pressure:

1. Pump: Non-atomizing, able to flow material on walls at minimum 1 to 1-1/2 gallons per minute.
2. Orifice size for concrete, slump block, exposed concrete aggregate, and cement plaster: 0.060 to 0.110 inches.
3. Orifice size for brick, clay brick tile, brick veneer, stone, and wood: 0.060 inches.

PART 3 EXECUTION

3.01 EXAMINATION

A. Carefully inspect installed construction. Verify that construction is ready for repellent application.

B. Require manufacturer's representative to verify that water repellent may be installed.

3.02 PREPARATION

A. Allow concrete or masonry walls to cure at least 30 days before applying water repellent.

B. Clean wall surfaces of soil, mud, efflorescence, or other detrimental materials.

C. Tuck-point or caulk cracks, other than hairline cracks.

D. Route out defective mortar joints, point with mortar and tool.

E. Moisture content: Apply water repellent sealer when moisture content of substrate is 15 percent or less.

3.03 APPLICATION ON CONCRETE MASONRY

A. Apply water repellent in accordance with manufacturer's printed instructions.

B. Apply flood coat using low-pressure spray equipment.

C. Start at top of wall and work down using overlapping horizontal passes.

D. Hold spray head 8 to 10 inches from surface so saturation coat runs freely down wall 6 to 10 inches below point of application on most substrates.

E. Spray by traveling horizontally to ensure uniform coverage.

F. Overlap each following pass by centering spray head on bottom line of the previous pass.

G. Trigger gun off at end of each pass to avoid applying excessive amount of material. Do not over apply.

H. Avoid application in hot or windy weather as premature drying can cause whitish residue on walls.

3.04 FIELD QUALITY CONTROL

A. Twenty days after application, test water repellent on CMU surfaces using RILEM Test Method No. 11.4.
   1. Contractor shall perform a 20-minute RILEM baseline test on dry untreated CMU units of each type to receive water repellent. Test results (water loss in mililiter) shall be compared to CMU units in walls after water repellent application.
   2. On water repellant coated CMU, a RILEM tube test resulting in 5 mililiter or less after 20 minutes is necessary to qualify for 5-year warranty.

B. Notify the Engineer and manufacturer at least 72 hours in advance of test.

C. Where tested wall areas fail to pass RILEM tube test, apply additional coat of water repellent on entire wall from corner to corner.

D. Test all locations where directed by the Engineer.

3.05 CLEANING

A. Concrete masonry: Clean drips, runs, and overspray residue while still wet, using detergent and water. Clean application and spray equipment with detergent and water immediately following use.

B. Clean application and spray equipment according to the manufacturer's recommendations.

C. Remove excess materials, equipment, and debris incidental to water repellent application upon completion.

3.06 PROTECTION

A. During application, protect water repellent treated and adjacent surfaces from damage.

B. Protect glass, aluminum, and other surfaces from overspray.

C. Protect concrete sidewalks from runoff. Soak with water immediately prior to application on adjacent walls.

D. Repair damaged areas promptly.

END OF SECTION

SECTION 07220

ROOF AND DECK INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Roof and deck insulation and associated accessories.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01312 - Project Meetings.
      b. Section 07530 - Elastomeric Membrane Roofing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. D 41- Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
   3. D 312 - Standard Specification for Asphalt Used in Roofing.

B. FM Global (FM).

C. National Roofing Contractors Association (NRCA).

D. Underwriters Laboratories, Inc. UL.

1.03 SYSTEM DESCRIPTION

A. Roof insulation system: As follows with UL Class A and FM Class 1A fire classification and meeting FM 1-90 wind up-lift requirements.
   1. Where tapered rigid foam insulation is indicated on the Drawings, insulation shall be as follows:
      a. Multiple layer insulation, comprised of layers of flat and tapered rigid foam roof insulation, built up to provide a taper, sloped to drains, of 1/4-inch per foot minimum.
      b. Minimum insulation thickness at roof drains shall be 1-1/2 inches.
      c. Provide drainage pattern as indicated on the Drawings.

1.04 SUBMITTALS

A. Product Data.

B. Samples. Include 6-inch square samples of each type and thickness of insulation required.

C. State thickness and R-value of insulation to be provided at each building.

D. Manufacturer's Installation Instructions: Include the following:
   1. Indicate special environmental conditions required for installation.
   2. Indicate adhesive recommendations.
   3. Indicate fastener recommendations and attachment pattern to meet specified FM 1-90 requirements.
   4. Indicate installation techniques.

E. Certificates:
   1. Certify that products meet or exceed specified requirements.
   2. Certify that insulation is approved by manufacturer for use with specified roofing materials.

F. Manufacturer's Field Reports.

G. Warranty.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications:
   1. Manufacturer-approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.
   2. Committed to complying with manufacturer's specifications and NRCA recommendations.
   3. Committed to assuming undivided responsibility for roof insulation, roofing membrane and sheet metal flashing, and trim associated with roofing.

C. Product compatibility: Provide roofing manufacturer approved roof insulation.

D. Pre-installation conference: Conduct as specified in Section 01312.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's instructions.

B. Label asphalt containers with certification of full compliance with requirements of ASTM D 312, Table 1, and indicating equiviscous temperature, finished flowing temperature, and flash point.

C. Store roof system materials on pallets or dunnage at least 4 inches above ground and suitably covered to protect from weather.

1.07 SEQUENCING AND SCHEDULING

A. Apply no more insulation than can be completely covered with roofing membrane on the same day.

B. When installation of insulation and roof membrane cannot be completed within same day, install temporary water cutoffs at end of day's work and remove cutoffs prior to resumption of work.

1.08 WARRANTY

A. Furnished by roof membrane manufacturer, as specified in Section 07530.

PART 2 PRODUCTS

2.01 MATERIALS

A. Tapered foam roof insulation:
   1. Closed cell polyisocyanurate foam core bonded to universal fiberglass reinforced facers. Minimum thickness of 2" shall be provided.
   2. Utilizing environmentally compliant blowing agent.
   3. Manufacturers: One of the following or equal:
      a. Johns Manville, Inc., Denver, CO, Tapered ENRGY 3.
      b. Atlas Roofing Corporation, Atlanta, GA, Tapered ACFoam II.

B. Mineral board: Factory fabricated, 1/2-inch thick, glass mat faced, noncombustible, moisture resistant, silicone treated, gypsum core panel.
   1. Manufacturers: The following or equal:
      a. Georgia-Pacific, Atlanta, GA, Dens-Deck Roof Board.

C. Roof crickets and saddles: Tapered Perlite Roof Insulation or as otherwise recommended by roofing manufacturer to meet warranty requirements.

D. Primer: ASTM D 41, asphalt primer.

2.02 ACCESSORIES

A. Screw fastener system for steel decks:
   1. Self-drilling and self-tapping, zinc plated or stainless steel screws, sized for 1/2- to 3/4-inch exposure on exposed to view underside of deck, with minimum 3-inch square or diameter ribbed steel stress plates, hot-dip galvanized with minimum G-60 coating in accordance with ASTM A 123.
   2. Manufacturers: One of the following or equal:
      a. Tru Fast, Bryan, OH.
      b. TW Buildex, Itasca, IL.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that deck surfaces are clean, dry, and where required, coated with primer.

3.02 INSTALLATION OVER STEEL DECK

A. Install roof insulation in accordance with manufacturer's specifications.

B. Secure wood nailers to roof deck adjoining eaves, , and at other locations indicated on the Drawings.
   1. Nailers shall be built up of pressure treated wood to match the thickness of the insulation.

C. Apply first layer of roof insulation with long joints continuous, either parallel or at right angles to ribs of deck.

D. Form joints parallel to ribs over solid bearing.

E. Stagger end joints.

F. Secure with approved mechanical fasteners in FM I-90 pattern:
   1. Space fasteners as recommended by insulation manufacturer.
   2. Drive fasteners through tin caps or plastic fastener/cap assemblies, unless they are provided with integral flat cap not less than 1 inch across.
   3. Install screw fastener system in top rib of steel deck in accordance with manufacturer's instructions. Where underside of metal deck is exposed to view, size fasteners to penetrate deck from 1/2- to 3/4-inch, unless otherwise recommended by fastener manufacturer.

G. Apply second layer of roof insulation with both long and short joints offset from joints of first layer. Firmly set in full width mopping of hot asphalt applied at approximately 33 pounds per square.

H. Install cant strips at curbs, parapets, and intersections of roofs and vertical walls, when recommended by membrane manufacturer. Place on top of insulation and set in solid mopping of asphalt.

I. Roof crickets:
   1. Install as required to achieve drainage pattern indicated on the Drawings, and as otherwise required to obtain roof warranty. Set in full mopping of hot asphalt. Feathered edges of crickets and tapered insulation shall be formed of perlite or fiber board.
   2. Mop 12-inch wide felt strip into solid asphalt at valley formed by installation of roof crickets to provide additional membrane reinforcement.

J. Before application of roofing, turn over and solidly mop projecting felt to insulation at vertical surfaces and edges.

K. Do not leave insulation exposed to weather.

3.03 FIELD QUALITY CONTROL

A. Roof insulation which becomes wet or damaged shall be removed and replaced with solid, dry insulation, unless installer provides written acceptance of the damaged insulation from the roofing manufacturer, whose warranty shall cover the system.

B. Inspections: Roof membrane manufacturer, whose warranty shall cover complete roof assembly, shall provide supervision and inspection necessary to secure warranty.

END OF SECTION

SECTION 07530

ELASTOMERIC MEMBRANE ROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Mechanically-attached, single-ply elastomeric membrane roofing system.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01312 - Project Meetings.
      b. Section 07220 - Roof and Deck Insulation.
      c. Section 07600 - Flashing and Sheet Metal.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 751 - Standard Test Methods for Coated Fabrics
   2. D 573 - Standard Test Method for Rubber-Deterioration in an Air Oven.
   3. D 1149 - Standard Test Method for Rubber Deterioration-Surface Ozone Cracking in an Ozone Controlled Environment.
   4. D 2136 - Standard Test Method for Coated Fabrics-Low-Temperature Bend Test.
   5. D 2240 - Standard Test Method for Rubber Property-Durometer Hardness.

B. FM Global (FM):
   1. FTM 101 B - Test Method 2031 for Puncture Resistance.

1.03 SYSTEM DESCRIPTION

A. Fire Hazard Classification:
   1. UL Class A..
   2. FM Class 1A.

B. Wind up-lift requirement: FM 1-90.

1.04 SUBMITTALS

A. Product data: Include specifications and flashing details.

B. Samples: Each type of membrane material, 8 inches square.

C. Manufacturer's Installation Instructions.

D. Certificates: UL and FM listings.

E. Maintenance manual: Include repair instructions.

F. Warranties.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer-approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

C. Pre-installation conference: Conduct as specified in Section 01312.

D. Verify roof and deck insulation in Section 07220, and flashing and sheet metal in Section 07600 are compatible with membrane roofing.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Deliver materials with appropriate labels indicating warnings, storage conditions, lot numbers, and usage instructions.

1.07 WARRANTIES

A. Manufacturer's warranty: Minimum 10 years to correct defective roofing materials, including installation.

B. Roofer's warranty: Minimum 2 years to correct defective workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURER AND TYPE

A. Type: Mechanically attached, heat-welded seam, white, reinforced thermoplastic polyolefin (TPO) membrane assemblies.

B. Manufacturers: One of the following or equal:
   1. Carlisle Corp., Carlisle, PA, Sure-Weld.
   2. Johns Manville, Willows, CA JM TPO.

2.02 COMPONENTS

A. Scrim-Reinforced Thermoplastic Polyolefin (TPO) Sheet: 60 mil, scrim-reinforced, white, membrane 12-feet wide maximum by appropriate length conforming to following minimum physical properties:
   1. Tensile Strength: Minimum of 300 lbf as tested using ASTM D751.
   2. Tear strength: Minimum 45-60 pounds when tested in accordance with ASTM D 751.

B. Roof walkway: To be provided at all traffic concentration points and regular maintenance.
   1. Siplast: Trafbloc.
   2. Johns Manville, Walkpad, skid resistant gray walking surface.

C. Flashing, bonding adhesive, sealant, primer, seam caulk, and mechanical fasteners: Membrane manufacturer approved.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify the following:
   1. Maximum 1/4-inch insulation joint widths.
   2. Proper installation of nailers and cants.
   3. Dry, clean, and smooth substrate without sharp edges and debris.

3.02 INSTALLATION

A. Install roofing in conformance with manufacturer's instructions.

B. Install perimeter sheets.

C. Lay field sheets with long edges perpendicular to roof slope, with edge of roll aligned with perimeter sheets.

D. Install screw fasteners, spaced in accordance with manufacturer's recommendations, along leading edge of membrane, through insulation, and into roof deck.

E. Overlap fastened edges of installed membrane by approximately 4-1/2 inches. Hot air weld edges with manufacture approved automatic hot air welder.

F. Prime cured material as required before hot air welding.

G. Seal cut edges with seam caulk.

H. Install metal flashing as specified in Section 07600.

I. Fasten and finish perimeter in accordance with membrane manufacturer's standard details.

J. Where underside of metal deck is exposed to view, size fasteners to penetrate deck not more than 3/4 inch.

K. Cut walkway material into sections (maximum 36 inch). Heat weld in place with 6-inch gap between sections to allow proper drainage.

3.03 FIELD QUALITY CONTROL

A. Arrange for manufacturer's warranty supervision and inspection.

END OF SECTION

SECTION 07600

FLASHING AND SHEET METAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: flashing, sheet metal, and associated accessories.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 03102 - Concrete Formwork.
      b. Section 04220 - Concrete Unit Masonry.
      c. Section 07530 - Elastomeric Membrane Roofing.
      d. Section 07700 - Roof Specialties and Accessories.
      e. Section 07900 - Joint Sealants.

1.02 REFERENCES

A. Aluminum Association (AA).

B. ASTM International (ASTM):
   1. A 240 - Standard Specification for Chromium and Chromium-nickel Stainless Steel Plate, Sheet, and Strip For Pressure Vessels and General Applications.
   2. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   3. B 32 - Standard Specification for Solder Metal.
   4. B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   5. B 221 - Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   6. B 224 - Standard Classification of Coppers.
   7. B 370 - Standard Specification for Copper Sheet and Strip for Building Construction.
   8. B 749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.
   9. D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
   10. D 4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free.

C. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Show fabrication details, material profiles, connections, jointing pattern, jointing details, fastening methods, isolation methods, and installation details.

C. Manufacturer's Installation Instructions.

1.04 SEQUENCING AND SCHEDULING

A. Coordinate sheet metal installation with installation of materials specified in Sections 03102, 04220, 07530, 07700, 07900.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Stack preformed material to prevent twisting, bending, or abrasion, and to provide ventilation.

B. Prevent contact with materials during storage which may cause discoloration, staining, or damage.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aluminum extrusions: ASTM B 221, alloy 6063-T42.

B. Aluminum sheet: ASTM B 209, 5005-H14 alloy and temper; minimum 32 mils thick, millfinish.

C. Galvanized steel sheet: ASTM A 653, G-90 minimum 24 gauge thick, with 1.25 ounce coating.

2.02 ACCESSORIES

A. Fasteners and metal washers: Types best suited for purpose, of same material as sheet metal being fastened or of composition that will not support electrolysis, such as Type 18-8 stainless steel for fastening aluminum.

B. Sealer washers: Rubber type, minimum 0.040 inch thick.

C. Underlayment: ASTM D 226; Number 30 asphalt saturated roofing felt. Protective backing paint: Bituminous.

D. Slip sheet: Rosin sized building paper.

E. Bedding compound: Rubber-asphalt type.

F. Roof cement: ASTM D 4586, plastic asphaltic cement.

G. Solder: ASTM B 32.

2.03 FABRICATION

A. Form sheet metal true to shape, accurate in size, square, and free from distortion or defects.

B. Form rises and angles into flashing true and straight, with exposed surfaces free from waves and buckles.

C. Fabricate cleats and starter strips of same material as sheet, minimum 3 inches wide, interlockable with sheet.

D. Form pieces in longest practical lengths. Size and space joints to provide adequate movement for thermal expansion and contraction.

E. Hem exposed edges on underside 1/2 inch; miter and seam corners.

F. Form material with flat lock seams.

G. Solder and seal metal joints. After soldering, remove flux. Wipe and wash solder joints clean.

H. Fabricate corners from 1 piece with minimum 18 inch long legs; seam for rigidity, seal with sealant.

I. Fabricate vertical faces with bottom edge formed outward 1/4 inch and hemmed to form drip.

2.04 FINISH

A. Backpaint concealed metal surfaces with protective backing paint to minimum dry film thickness of 15 mil.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set, cant strips and reglets in place, and nailing strips located.

B. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 INSTALLATION

A. Install flashing and sheet metal in accordance with AA and SMACNA references, and when in connection with roofing, roofing manufacturer's specifications.

B. Install sheet metal to even smooth, sound, thoroughly clean and dry surfaces, free from defects that could affect installation.

C. Install flashings where necessary to provide leakproof conditions.

D. Isolate dissimilar metals from direct contact with protective backing paint.

E. Install starter, edge strips, and cleats before starting installation.

F. Perform cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate work of other sections.

G. Install sealer washers under metal washers or fastener heads where weathertightness is required.

H. Secure flashings in place using concealed fasteners. Use exposed fasteners only in locations acceptable to the Engineer.

I. Seam and seal joints. Make connections watertight and weathertight.

J. Apply roof cement compound between metal flashings and felt flashings.
   1. Fit flashings tight in place.
   2. Make corners square, surfaces true and straight in planes, and line accurate to profiles.

K. Seal metal joints watertight.

END OF SECTION

SECTION 07610

PUMP STATION SHEET METAL ROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Furnish and install roofing panels, clips, fasteners, flashing, closures, insulation, and related accessories required for a complete roofing system as indicated on the contract documents.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 05500 - Metal Fabrications.
      b. Section 07600 - Flashing and sheet metal.
      c. Section 07900 - Sealants.

1.02 REFERENCES

A. Building Design Codes, Uplift, Live and Dead Loads.
   1. ASCE 7-03 Minimum Loads for Buildings and Other Structures (ASCE 7-10) American Society of Civil Engineers (ASCE),

B. Reference Standards
   1. American Iron and Steel Institute (AISI), Specification for the Design of Cold-Formed Steel Structural Members (Aug. 1986).
   2. American Society for Testing and Materials (ASTM) (Current Edition)
      a. E1592 "STand

1.03 QUALITY ASSURANCE

A. Manufacture's Qualifications
   1. The manufacture shall have had at least (5) years experience in architectural and industrial roofing systems.

B. Installer Qualifications
   1. The installer shall have a minimum (5) years experience of installation with structural field-formed concealed clip roofing systems.
   2. Manufacturer must train and certify the installer so as to provide a single source responsibility for this portion of the work.

1.04 SUBMITTALS

A. ASTM E1592 "Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference" test methods.

B. Halter/Clip Fastener Pull-Out Tests and Calculations.

C. UL 90 Classification Test Data and report number.

D. Concentrated Load Test Data.

E. Air Infiltration (E283) and Water Penetration (E331) Test Results.

F. Shop Drawings
   1. Complete shop drawings, catalog cuts, calculations with all details, roof plans, wall elevations, and field installation notes clearly indicated.
   2. Performance Requirements - Submit structural design calculations and test reports certified by a registered professional structural engineer licensed in the State of Arizona to verify load - carrying capacities and thermal movement allowance of the panel system.
   3. Certified laboratory test reports showing that the proposed system has been tested and conformed to applicable provisions specified herein.
   4. Samples or descriptive data;
      a. Roof panel: Full panel width, 12 inches long.
      b. System Clips/Halters: Two required.
      c. Fasteners: Two of each type to be used with a statement identifying the intended use of each.
      d. Closure: One metal and one neoprene.
      e. Sealants: One sample of each type and statement identifying the intended use of each.

G. Manufacturer's Warranty: Standard performance warranty provided by the manufacturer to warrant all panels, flashings, sealants, fasteners, and accessories against defective materials and/or workmanship for a period of two (2) years Manufacturer's standard warranty must accompany submittal package.

PART 2 PRODUCTS

2.01 MANUFACTURER'S

A. Bemo USA Corp., Mesa AZ

B. RDLLFAB Metal Products, Pheonix, AZ

C. Atas International, Allentown, PA

D. Requests to use alternate systems must be submitted in writing to the project designer at least ten (10) days prior to the bid date. Performance requirements, certified statements, samples, sample warranties, and descriptive date must accompany the request for substitution.

2.02 PRODUCT PERFORMANCE DESIGN

A. The standing team roof system shall be designed to safely resist the positive and negative loads as required for the location and type of project designed.

B. Structural-uniform uplift load capacity of the panel system shall be determined in accordance with the principles of ASTM E1592, "Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference" as follows:

C. The factor of Safety on the test results shall be 1.65 for the panel and clip/halter ultimate loads with not increase for wind.
   1. The Factor of Safety for fasteners shall be 3.0 for single fastener in each connection, 2.25 for 2 or more fasteners in each connection and 4.0 in masonry.
   2. Design uplift capacity for condition of gage, span or loading other than those tested may be determined by interpolation of test results.
   3. Deflection shall be 1/180 for positive loading.

D. Water penetration of the panel assembly at 20 psf pressure for 15 minutes shall have "no uncontrollable leakage" when tested in accordance with ASTM E331.

E. Air infiltration of panel assembly at 20 psf pressure shall be no more than 0.02 cfm/sf of panel when tested in accordance with ASTM E283.

F. The panel system shall have a U.L. Class 90 rating.

G. Panels are to be fabricated full length with absolutely no end lap conditions allowed. The manufacturing equipment must be owned and operated by the manufacturer who must train and certify the installer and take complete responsibility for the entire workscope.

H. Fasten the roofing panels to the structure through the use of concealed halters/clips which are designed to allow for up to and including a full 3-3/4" of panel movement without impending the performance of the panel.

I. Curved panels, concave, convex or both are to be manufactured in one continuous panel length and curved without crimping or distorting the standing seam legs of the roof panels.

2.03 MATERIALS

A. Metal Roof panels are to be manufactured and installed by trained and Certified contractors.
   1. Fabricate metal panels from a minimum of ☐ .040" thick aluminum alloy 3004-H-14. Smooth finish.
   2. Panels shall be maximum of 16" wide (400 mm) with a minimum vertical standing leg height of 2 1/2".

B. Concealed Clips
   1. Fasten standing seam roofing to structure with specially designed and tested clips manufactured exclusively for the roofing system.

2. Clips/halters must be designed to allow the roofing materials free movement in either direction parallel to the standing leg of the panel. Sliding Hood Clips to be a minimum of 18 ga. Type 301 stainless steel and allow for a minimum of 3-3/4" of thermal movement. Aluminum halters are to provide for unlimited thermal expansion.

C. Finish
   1. Exterior Surface of Panels: Consisting of a nominal .2 mil primer and nominal .8 mil 70% polyvinylidene topcoat. The color shall be selected from Manufacturer's standard color chart.
   2. The coating system must have been tested to and exhibited the minimum characteristics of the following ASTM test criteria:
      a. Specular Gloss (ASTM D-523 @ 60 degrees), Standard gloss of 20-30.
      b. Pencil Hardness (ASTM D-3363), HB-H.
      c. Flexibility, T-Bend (ASTM D4145), No cracking or tape removal of fil at 1-T on painted aluminum and at 2-T on paint steel.
      d. Adhesion/Reverse Impact, (ASTM D-3359, D-2794), 1.5 times metal thickness with no loss of adhesion. No cracking or loss of adhesion.
      e. Abrasion/Falling Sand, (ASTM D-968), Liters to expose 5/32" of substrate-50.
      f. Acid Pollutants, (ASTM D-1308) 10% muriatic acid (15 min) no effect, 20% Sulfuric acid (15 min) no effect.
      g. Salt Spray Resistance 5% @ 95 degrees F (ASTM B-117). Passes 3,000 hrs on alum. And 1,000 hrs on coated steel.
      h. Humidity Resistance 100% @ 95 degrees F (ASTM D-2247). Passes 3,000 hrs on alum. And 1,000 hrs on coated steel.
      i. Weathering Tests (ASTM D-224 South Florida Exposure, D-822 Color Retention, D-659 Chalk Resistance), Less than 5NBS units change, Passes 5,000 hrs., Rating of 8 min.

D. The backside of the panels to have an EPA approved .2 mil Clear Coat.

E. Continuous applied weather seal to be installed during the manufacturing process of the panel system.

F. Flashing - All trim materials to be same gage and finish as specified for the panel system.

PART 3 EXECUTION

3.01 EXAMINATION

A. The installer shall examine the building to verify that the structure is ready for roofing installation.

B. Manufacturer/installer cannot proceed until all structural supports and/or substrates are satisfactorily installed in accordance with the drawings, specifications, and applicable industry standards.

C. Install all panels in one continuous unbroken length for any length of 250' or less.

D. Panels are to be mechanically seamed after installation in the field.

E. Replace any materials or components that are damaged beyond repair prior to completion.

F. Each area will be wiped down as it is completed.

END OF SECTION

SECTION 07700

ROOF SPECIALTIES AND ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Manufactured roof specialties and accessories, including the following:
   1. Metal coping.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01612 - Seismic Design Criteria.
      b. Section 07530 - Elastomeric Membrane Roofing.
      c. Section 07600 - Flashing and Sheet Metal.
      d. Section 07900 - Joint Sealants.

1.02 SUBMITTALS

A. Product data: Include finish and color options.

B. Shop drawings. Include metal coping installation details.

C. Samples: Include finish and color samples.

D. Manufacturer's Installation Instructions.

E. Warranties.

1.03 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

1.05 WARRANTY

A. Provide manufacturers' standard warranties that warranty against defects for longer than 1 year.

PART 2 PRODUCTS

2.01 METAL COPINGS

A. Manufacturers: One of following or equal:
   1. Peterson Aluminum Corp., Tyler, TX, Pac-Lok.
   2. MM Systems Corp., Tucker, GA, Snap-Lok.
   3. W. P. Hickman Company, Asheville, NC, Permasnap.

B. Characteristics:
   1. Capable of direct attachment to top of masonry walls.
   2. Meets FM Class 1A-90 requirements.
   3. Capable of counterflashing roofing.

C. Copings:
   1. Material: Aluminum, minimum 0.050 inch thick.
   2. Width: To suit wall thickness.
   3. Length: 144 inches.
   4. Face Heights: Sufficient to conceal nailers or roof decking.
   5. Corners: Mitered and welded with minimum 24-inch legs.
   6. Finish: Kynar 500, resin-base color coating. Color as selected from manufacturer's standard color line.

D. Splice plates: Same materials, width, face heights, and finish as coping, 6 inches long.

E. Seal strips: Extruded Butyl with protective paper.

F. Anchor plate: Galvanized steel. Same width, face height as coping, approximately 12 inches long.

G. Fasteners and anchors: Manufacturer's recommendation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install roof accessories and specialties accordance with manufacturers' instructions.

END OF SECTION

SECTION 07900

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Silicone sealant.
   3. Synthetic rubber sealing compound.
   4. Synthetic sponge rubber filler.
   5. Related materials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M 198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C 920 - Standard Specification for Elastomeric Joint Sealants.
   2. C 990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   4. D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 ACRYLIC-LATEX SEALANT

A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options. Manufacturers: One of the following or equal:
   1. Tremco, Tremflex 834.
   2. Pecora Corp., Number AC-20.
   3. Sonneborn, Sonolac.

2.02 SILICONE SEALANT

A. ASTM C 920, Type S, Grade NS, Class 25, single component silicone sealant. Manufacturers: One of the following or equal:
   1. Tremco, Proglaze.
   2. Pecora Corp., Number 864.
   3. Dow Corning, Number 795.
   4. General Electric, Number 1200 Series.

2.03 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
   1. Sika Corporation, Lyndhurst, NJ, Sikaflex 2c NS or SL
   2. Polymeric Systems, Inc., PSI 275.
   3. Pacific Polymers, Garden Grove, CA, Elastothane 227R.

B. Material: In accordance with ASTM C 920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
   1. Base: Polyurethane rubber.
   2. Solids: Minimum 97 percent.
   3. Application time: Minimum 2 hours.
   4. Cure time: Maximum 3 days.
   5. Tack free time: 24 hours.
   6. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
   7. Tensile strength: Non-sag 120 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D 412.
   8. Ultimate elongation: Minimum 490 percent when tested in accordance with ASTM D 412.
   9. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D 624, Die C.
   10. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.04 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. Manufacturers: One of the following or equal:
   1. Presstite, Number 750.3 Ropax Rod Stock.

B. Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.
   6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
   7. Size: Minimum 25 percent greater than nominal joint width.

2.05 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
   2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less then 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
   4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
   5. Complete caulking prior to painting.
   6. Verify that concrete is thoroughly cured prior to caulking.
   7. When filler compressible material is used, use untreated type.
   8. Apply caulking with pneumatic caulking gun.
   9. Use nozzles of proper shape and size for application intended.
   10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
   11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
   12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
   13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

A. Acrylic latex:
   1. Use where indicated on the Drawings.
   2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.

5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
1. Use where indicated on the Drawings.
2. Water-bearing and earth-bearing concrete structures.
3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
4. Joints between sheet metal flashing and trim.
5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
1. Use where indicated on the Drawings.
2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
4. Pavement joints.
5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

END OF SECTION

SECTION 08110

HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel Fire Resistive Rated and Non-Fire Resistive Rated:
   1. Doors.
   2. Door frames.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 04220 - Concrete Unit Masonry.
      c. Section 08710 - Door Hardware.
      d. Section 09910 - Painting.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A250.6 - Hardware on Steel Doors (Reinforcement Application).
   2. A250.8 - Recommended Specification for Standard Steel Doors and Frames.

B. ASTM International (ASTM):
   1. A 653/A653M - Standard Specification for Sheet Steel, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   2. A 924/A924M - Standard Specification for General Requirements for Steel Sheet, Metallic- Coated by the Hot-Dip Process.
   3. A 1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
   4. A 1011 – Standard Specification for Steel, Sheet and Strip, Hot Rolled, Carbon, Structural, High Strength Low Alloy, High Strength Low Alloy with Improved Formability, and Ultra High Strength.
   5. E 152 - Standard Methods of Fire Tests of Door Assemblies.
   6. E 413 - Classification for Rating Sound Insulation.
   7. E 1408 - Standard Test Method for Laboratory Measurement of the Sound Transmission Loss of Door Panels and Door Systems.

8. E 2074 - Standard Test Method for Fire Tests of Door Assemblies, Including Positive Pressure Testing of Side-Hinged and Pivoted Swinging Door Assemblies.

C. National Association of Architectural Metal Manufacturers (NAAMM)/Hollow Metal Manufacturers Association (HMMA):
   1. HMMA 861 - Guide Specifications For Commercial Hollow Metal Doors and Frames.

D. National Fire Protection Association (NFPA):
   1. 80 - Standard for Fire Doors and Other Opening Protectives.

E. Steel Door Institute (SDI):
   1. SDI-111 - A Steel Doors and Frame Details.
   2. SDI-117 - Manufacturing Tolerances Standard Steel Doors and Frames.

F. Underwriters' Laboratories, Inc., (UL):
   1. UL 10C - Positive Pressure Fire Tests of Door Assemblies.

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Show the following with references to the Engineer's door marks and hardware groups:
   1. Location of door and frame types.
   2. Details of fabrication, including core construction, glass lights, louvers, weatherstripping, and factory finish for each door.
   3. Cutouts and reinforcements for hardware.
   4. Methods of installation and anchorage to adjacent construction.

C. Certificates documenting:
   1. Fire-rated units have been successfully tested in accordance with paragraph 2.06.

D. Manufacturer's instructions: Submit manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

A. Testing agency qualifications: Approved by ultimate enforcing authority for the Project; regularly engaged in inspection of materials and workmanship at factory.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Before delivery, identify type and size of each door and frame in such a way that markings will not damage finish.

B. Preassemble doorframes in shop and deliver to Project site with spreader bar at sill or tie them in pairs to form box.

C. Protect doors and frames with resilient packaging sealed with heat shrunk plastic. Break seal on-site to permit ventilation.

D. Protect doors and frames during shipment and storage to prevent warping, bending, and corrosion.

1.06 SEQUENCING AND SCHEDULING

A. Ensure timely delivery of reviewed hardware schedule and hardware templates such that no delay occurs in the work of the Contract.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sheet steel: ASTM A 1008, commercial quality, level, cold rolled steel, or ASTM A 1011, hot rolled, pickled and oil rolled steel. Galvanize by hot-dip process with zinc-coating conforming to ASTM A 653 and A 924 A 60, with a coating weight of not less than 0.60 ounces per square foot (0.30 ounces per square foot per side). Clips, bolts, screws, and rivets: sized as recommended by manufacturer.

B. Primer: Rust- inhibitive metal primer capable of being baked and compatible with finish painting system specified in Section 09910.

C. Touch-up materials: Primer as recommended by manufacturer.

D. Door hardware: As specified in Section 08710.

E. Grout: As specified in Section 04220.

F. Glass and glazing materials: As specified in Section 08800.

2.02 DOOR AND FRAME TYPES

A. Exterior doors: ANSI 250.8, Grade III, Model 3, or NAAMM HMMA 810 Type A and NAAMM HMMA 861, flush steel rib-stiffened, minimum 16 gauge face sheets.

B. Exterior frames: ANSI 250.8 or NAAMM HMMA 861, fully welded frames HMMA 861, except minimum 14 gauge sizes and shapes as indicated on the Drawings.

2.03 COMPONENTS

A. Door cores:
   1. Stiffeners: Vertical steel ribs formed from minimum 22-gauge plain sheet steel, spaced at maximum 6 inches apart and securely attached to face sheets by spot welds at maximum 5 inches on center.
   2. Core fillers: Insulation, minimum 0.60 pound density noncombustible type, installed in spaces between stiffeners for full height of door; labeled door core material shall conform to requirements of labeling authority.

B. Glazing stops: Minimum 18 gauge sheet steel, mitered, square, or rectangular:
   1. Outside of exterior doors: Fixed, integral to doors and frames.
   2. Secure side of interior doors: Removable.

C. Removable stop fasteners: Flat head, countersunk, tamperproof, self-tapping sheet metal screws.

2.04 FABRICATION OF FRAMES

A. Galvanize all frames installed in exterior openings.

B. Frames: Sheet steel, integral type, welded continuous to full depth of frames with minimum 5/8-inch deep stops, unless otherwise indicated on the Drawings.

C. Hardware reinforcement: Minimum 7 gauge at hinges; 12 gauge at strikes, bolts, closers, and other applied hardware.

D. Jamb Anchors: As required for adjacent wall construction, minimum 3 per jamb, unless otherwise indicated on the Drawings;

E. Floor anchors: Fixed type, except where adjustable anchors are indicated on the Drawings, 1 per jamb, with minimum 2 holes for anchorage. Where floor fill occurs, terminate bottom of frames at indicated finished floor level and support by adjustable extension clips resting on and anchored to structural slabs.

F. Anchors at masonry: Adjustable strap and stirrup, minimum 16 gauge corrugated or perforated steel at maximum of 30 inches on center and extending minimum 8 inches into masonry.

G. Anchors at previously placed concrete: Countersink machine screws through the frame into expansion devices spaced at maximum 30 inches on center.

H. Masonry angle stiffeners: Factory welded into heads of frames for installation in openings more than 48 inches wide.

2.05 FABRICATION OF DOORS

A. Galvanize all doors installed in exterior openings.

B. Reinforce face sheets with steel rib stiffeners, spaced at maximum 6 inches apart, and securely attached to face sheets by spot welds at maximum 5 inches on center.

C. Fill voids between face sheets and stiffeners with fiberglass insulation having a minimum density of 0.8 pounds per cubic foot.

D. Edges: Full weld without visible joints. Bevel striking edge 1/8 inch in 2 inches.

E. Tops and bottoms of doors: Close with continuous recess steel channel of minimum 16 gauge, extending full width of door and spot welded to both faces.

F. Tops and bottoms of exterior doors: Flush closing channels welded to make tops and bottoms waterproof with weep holes for escape of moisture.

G. Hinge reinforcement: 7 gauge.

H. Lock, closer, and flush bolt reinforcement: 12 gauge.

2.06 HARDWARE PREPARATION

A. Cutout, drill, and reinforce frames and doors for hardware in accordance with hardware templates.

B. Install plaster guards or mortar boxes in back of hardware cutouts in and welded to frames.

C. Prepare fire resistive rated doors for hardware in accordance with requirements of labeling authority.

D. Do not weld hinges to doorframes.

E. Silencers:
   1. Drill single leaf doorframe jamb stops for minimum 3 silencers.
   2. Drill double-leaf doorframe head stops for minimum 2 silencers.
   3. Do not drill doorframes for silencers when weatherstripping is to be installed.

2.07 FINISHING

A. Thoroughly clean surfaces of oil, grease, and other impurities; touch-up abraded galvanizing; and chemically etch.

B. Fill irregularities and sand smooth finish surface. Apply 1 coat of manufacturer's standard rust inhibitive baked-on primer.

C. Finish painting: As specified in Section 09910.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine reviewed hardware schedules and verify proper coordination of hardware and doors and frames.

B. Examine opening locations and verify the following:
   1. Correctness of dimensions, backing, or support conditions.
   2. Absence of defects that would adversely affect frame or door installation.

3.02 INSTALLATION

A. Install doors and frames in accordance with approved shop drawings and manufacturer's instructions.

B. Frames:
   1. Set accurately in position, plumb, align, and attach securely to structure.
   2. Set in place before construction of adjacent masonry or framed walls.
   3. Anchor frames to previously placed concrete.
   4. Set frames before removing spreader bars.
   5. Fully grout frames in masonry as the Work progresses.
   6. Grout frames at concrete through keyways provided at head and jambs.

C. Doors: Install at correct openings, ensure smooth swing and proper closure with frame.

D. Door hardware: Install in accordance with Section 08710.

E. Separate or isolate dissimilar metals with neoprene gaskets, sleeves, and washers, or with coatings acceptable to the Engineer.

3.03 TOLERANCES

A. Manufacturing and installation tolerances: As indicated on the Drawings or in conformance to SDI 117 as minimum.

3.04 ADJUSTING AND CLEANING

A. Prime coat touch-up: Immediately after installation, sand smooth and touch-up rust areas, and other areas where primer has been damaged, with prime touch-up paint.

B. Make adjustments as required for correct, proper, and free function and smooth operation without binding of hardware or doors and frames.

C. Protect doors and frames from damage to surface or profile.

END OF SECTION

SECTION 08332

OVERHEAD COILING DOORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Non-fire rated insulated overhead coiling doors.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01612 - Seismic Design Criteria.
      b. Section 01614 - Wind Design Criteria.
      c. Section 08710 - Door Hardware.
      d. Section 09910 - Painting.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
   2. Type 4X enclosure in accordance with NEMA 250.
   3. Type 12 enclosure in accordance with NEMA 250.
   4. MG 1 – Motors and Generators

B. ASTM International:
   1. ASTM A 123 – Standard specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. ASTM A 653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
   3. ASTM A 666 – Standard specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   4. ASTM A 924 – Standard Specification for General Requirements of Steel Sheet, Metallic-Coated by the Hot-Dip Process (Referenced by ASTM A 653).

1.03 DEFINITIONS

A. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.
   2. Type 12 enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Compatibility with space and service requirements:
      a. Doors and equipment items provided shall be compatible with space limitations specified and indicated on the Drawings.
      b. Make modifications to doors and equipment items necessary to conform with space limitations or with utility services specified for rough-in.
      c. Provide items complete including all necessary ancillary equipment as may be required for complete and trouble-free operation.
   2. Maintenance requirements: For ease of maintenance, provide overhead coiling doors complying with following requirements:
      a. Provide each door assembly as complete unit produced or supplied by a single manufacturer, including frames, sections, brackets, operating mechanisms, hardware, except hardware items specified in Section 08710, and all necessary accessories for installation of complete in openings indicated.
      b. Unless otherwise specified, all doors of particular type throughout the entire project shall be as manufactured or supplied by a single manufacturer.

1.05 SUBMITTALS

A. Product data:
   1. General: Submit data completely describing products, including rough-in diagrams.
   2. Electrical operators: Submit complete manufacturer's data for all components for electric door operators. Show motor size and characteristics. Show manufacturer's verification that motor has been adequately sized for each size and type of door required. Submit electrical schematic diagrams.

B. Shop drawings:
   1. Drawings showing complete installation details, required clearances, relation to building structure, complete electrical rough-in requirements required for installation of motor operators for doors and for connection of such doors to fire alarm system, referenced to the door mark number.
   2. Show location and size of access doors required to perform maintenance on doors and auxiliary equipment.

C. Samples: Submit samples of finishes for finish selection.

D. Quality control submittals:
   1. Manufacturer's instructions:
      a. Installation instructions for each type and size of door, including manufacturer's data, operating instructions, and maintenance data.
      b. Furnish installer copy of diagrams and installation instructions.

E. Contract closeout submittals:
   1. Project record documents:
      a. Operation and maintenance data: Provide manufacturer's operation and maintenance data for each different type of door specified, complete with manufacturer's list of recommended spare parts and their prices, electrical

schematic diagrams, and name and address of nearest maintenance organization approved by door manufacturer.

b. Warranty: Provide manufacturer's standard warranty.

1.06 QUALITY ASSURANCE

A. Regulatory requirements:
   1. Wind loading as specified in Section 01614.
   2. Seismic requirements for door anchorage and support systems as specified in Section 01612.
   3. Provide electrical materials in NEMA Type enclosures as specified.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing, shipping, and storage: Protect doors during shipment and storage to prevent warping, bending, and corrosion.

B. Deliver materials only after proper facilities are available. Provide clean dry surfaces or platform as required and protect from deterioration and foreign matter.

1.08 PROJECT CONDITIONS

A. Field measurements: Field verify all opening dimensions and clearances prior to fabricating doors. Fitting doors to openings is the responsibility of the Contractor.

1.09 SEQUENCING AND SCHEDULING

A. Inserts and anchorages: Furnish inserts and anchoring devices which must be set into concrete or built into masonry. Provide setting drawings, templates, and directions for installation of anchorage devices. Coordinate delivery with other work to avoid delay to the Contract.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Acceptable Manufacturer: One of the following or equal:
   1. Overhead Door Corp., Lewisville, TX 75067.
   2. Wayne-Dalton Corp., Mt. Hope, Ohio 44660.
   3. The Cookson Company, Inc., Phoenix, Arizona 85043.

B. Steel overhead coiling door:
   1. Mounting: Face of wall.
   2. Operation: As indicated on the Drawings.
   3. Curtain:
      a. Exterior Slats: Manufacturer’s standard, minimum 20-gauge steel galvanized In accordance with ASTM A 653, interlocking flat-faced slats with ends of alternate slats fitted with metal end locks to hold curtain in alignment.
      b. Bottom bar: Steel galvanized In accordance with ASTM A 123, fitted with 2 equal-sized steel angles minimum 1/8-inch thick, with lift handle and slide bolt at either end and provided with a flexible PVC bulb type astragal

to ensure a consistent seal along the floor. Extrusion designed to interlock with door curtain.

c. Weatherstripping:
   1) Bottom bar: Manufacturer's standard, provided with a flexible PVC bulb type astragal to ensure a consistent seal along the floor. Extrusion designed to interlock with door curtain.
   2) Door jambs: Manufacturer's standard vinyl extrusion seals, manufacturer's standard.
   3) Hood: Manufacturer's standard vinyl air baffle.

4. Guides: Steel galvanized In accordance with ASTM A 123, formed of roll formed steel channels and angles or structural angles of sufficient depth to provide a groove of adequate depth on each jamb to hold curtain firmly in guides under design wind pressure.
5. Brackets: Steel galvanized In accordance with ASTM A 123, steel plate with permanently sealed ball bearings designed to enclose ends of coil and provide support for counterbalance pipe at each end.
6. Barrel and counterbalance mechanism: Steel pipe of sufficient size to carry door load with maximum deflection of 0.03 inch per foot of opening width and counterbalanced by helical springs, oil tempered torsion type designed with minimum safety factor of 1.25 percent, and having cast iron barrel plugs that anchor springs to tension shaft and pipe.
7. Hood: Manufacturer’s standard, minimum 24-gauge steel galvanized In accordance with ASTM A 653, designed to enclose curtain coil and counterbalance mechanism.

C. Insulation:
1. Interior slats: material to match exterior slats as specified in previous article, interlocking flat-faced slats, manufacturer's standard size with ends of alternate slats fitted with metal end locks to hold curtain in alignment.
2. Insulation: CFC-free Polyethylene foam yielding a minimum R-value of 6.20.

D. Door operators:
1. Chain operator: Unless otherwise indicated on the Drawings, use at doors 56 square feet or larger in area. Provide a continuous hand chain and gearing on coil side of door.

2.02 ACCESSORIES

A. Fasteners: Sizes and types as recommend by reviewed door manufacturer.

2.03 FINISHES

A. Slats, Hood and Bottom Bar:
1. Galvanized steel: Manufacturer’s standard rust inhibitive prime coat and with powder coat finish as selected by Owner from manufacturer’s standard colors.

B. Guides and Bracket Plates:
1. Galvanized steel: manufacturer's standard rust inhibitive prime coat in a flat black finish.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine openings to receive overhead coiling doors and verify:
   1. Dimensions and correctness of backing or support conditions.
   2. Absence of defects that would adversely affect installation.

B. Do not start the work until unsatisfactory conditions are corrected.

3.02 PREPARATION

A. Verify dimensions and design for each opening.

B. Coordinate details with other work supporting or adjoining coiling doors.

C. Furnish fastening devices as required to mount doors properly.

3.03 INSTALLATION

A. Install doors in strict accordance with manufacturer's installation instructions, unless specifically otherwise indicated on the Drawings.

B. Install assemblies plumb, square, and level at their proper elevations and in their proper planes.

C. Securely anchor assemblies to interior face of openings, in manner that provides full opening clearance, perfectly aligned and adjusted for smooth operation.

D. Interface with other products: Separate or isolate dissimilar metals with neoprene gaskets, sleeves, or washers, or with an acceptable coating.

3.04 ADJUSTING

A. Verify that door assemblies are securely anchored to structure, guides are perfectly aligned, and doors are adjusted for smooth operation.

B. Upon completion of installation, ensure doors are free from warp, twist, or distortion and are lubricated and properly adjusted to operate freely.

3.05 CLEANING

A. Thoroughly clean surfaces of grease, oil, and other impurities.

B. Replace any damaged or otherwise disfigured doors with new prior to final acceptance.

3.06 DEMONSTRATION

A. Provide Owner's maintenance employees with minimum of 8 hours of maintenance instruction.

3.07 PROTECTION

A. Protect installed doors from damage until final acceptance.

END OF SECTION

SECTION 08710

DOOR HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Door hardware.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 08110 - Hollow Metal Doors and Frames.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E 90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
   2. E 283 - Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.

B. Builders Hardware Manufacturers Association (BHMA):
   1. A156.7 - Template Hinge Dimensions.
   2. A156.18 - Materials and Finishes.

C. Underwriters Laboratories, Inc.

1.03 SUBMITTALS

A. Product Data.

B. Hardware schedule: Include references to Engineer's hardware group number, door type designations, locations, other pertinent data, and manufacturer names or suitable abbreviation opposite items scheduled.

C. Keying Schedule: Include list giving key code and numbers of doors which can be opened by each key.

D. Samples: Include for each different type and manufacturer for review of finish.

E. Construction key distribution list: Submit upon Owner's request.

F. Templates:
   1. Furnish hardware templates to fabricators of doors, frames, and other work to be factory-prepared for hardware.
   2. Check shop drawings of other work to confirm that adequate hardware backing is available.

G. Project record documents: Include corrected hardware schedule.

1.04 REGULATORY REQUIREMENTS

A. Provide hardware for fire-resistive rated openings that complies with UL and listed by UL.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver hardware where directed in unopened packages with items packed separately, complete and ready for installation with necessary fittings, trim, fasteners, and accessories.

B. Provide packages bearing the manufacturers' labels with each item or group of items identified according to the accepted hardware schedule.

1.06 MAINTENANCE

A. Require lockset manufacturers to deliver permanent keys to Owner directly.

1.07 SCHEDULING AND SEQUENCING

A. Upon receipt of accepted hardware schedule, coordinate accepted hardware schedule, templates, reinforcing units, and template instructions to door and frame sections.

B. Restrict distribution of construction keys to superintendents and foremen. Maintain record of persons who have received keys on construction distribution list.

PART 2 PRODUCTS

2.01 FASTENERS

A. Types:
   1. To concrete, marble, or masonry: Machine screws and flush shells.
   2. To mineral and hollow core doors: Sex bolts.
   3. Of exit devices to doors: Thru-bolts, unless otherwise specified.

B. Screws, exposed: Phillips-head type, full-threaded screws, not combination type.

C. Sizes: Suitable for heavy use.

D. Finish: Stainless steel, unless otherwise required to match material and hardware finish.

2.02 HINGES

A. Manufacturers: One of the following or equal:
   1. Stanley.
   2. Hager.
   3. McKinney.
   4. Ives.

B. Material:
   1. Exterior doors: Stainless steel.

C. Knuckles, number of: Minimum 5.

D. Ball bearings: Concealed with interior self-lubricating bushings.

E. Type for doors with closers: Ball bearing.

F. Material for fire-resistive rated doors: Steel.

G. Pins for interior doors: Non-rising.

H. Pins for exterior doors: Non-removable.

I. Template hinges: BHMA A156.7.

J. Tips: Flat button.

K. Height: As follows, unless otherwise specified:
   1. Doors 1-3/8-inch thick: 3-1/2 inches.
   2. Doors 1-3/4-inch thick and up to 41 inches wide: 4-1/2 inches.
   3. Doors 1-3/4-inch thick and from 41 to 48 inches wide: 4-1/2 inches, extra heavy.
   4. Doors 2 inches thick or over 48 inches wide: 5 inches, extra heavy.

L. Widths: Sufficient to clear trim projection when door swings 180 degrees, unless otherwise specified.

M. Number per door leaf: As follows, unless otherwise specified:
   1. 3 hinges on door to 7 feet, 6 inches in height.
   2. 1 additional hinge for each additional 2 feet, 6 inches of height or fraction thereof.

2.03 CONSTRUCTION KEYING

A. Type: **Removable core** system.

2.04 PERMANENT KEYING AND KEYS

A. Keying schedule: Key to match existing system, coordinate with Owner.

B. Number of keys:
   1. Grand master keys: 4.
   2. Keyed alike: 8 keys for each keyed alike group furnished.

3. Keyed different: 2.

C. Identification:
   1. Emboss face of each cylinder plug and key with minimum 3-digit visual key control system.
   2. Emboss DO NOT DUPLICATE on keys.

2.05 CLOSERS

A. Manufacturers:
   1. Features:
      a. Heavy-duty.
      b. Non-handed and non-sized.
      c. Adjustable spring power from size 1 through 4.
   2. One of the following or equal:
      a. Sargent, 351 Series.
      b. LCN, Super Smoothee Model 4041 Series.
      c. Norton Door Controls, Multi-Size Door Closers Model 7500BF Series.

B. Type: Full rack and pinion type with steel spring and non-gumming, non-freezing hydraulic fluid.

C. Controls: Separate set for regulating sweep speed, latch speed, backcheck and backcheck positioning, or where schedules, spring power.

D. Sizes: As recommended by accepted manufacturer.

E. Covers: Plastic, capable of being spray painted to match adjacent hardware finishes, unless otherwise specified.

F. Narrow frame provisions: Drop plates.

G. Effort to operate: As follows:
   1. Exterior: Maximum 8-1/2 pounds.
   2. Interior: Maximum 5 pounds.
   3. Fire-resistive rated doors: Maximum 15 pounds.

H. Adjust closers in accordance with manufacturer's directions for size of door.

2.06 EXIT DEVICES

A. Lever design:
   1. Manufacturers: The following or equal:
      a. Von Duprin, Lever Model 06.

B. Mortise lock device, non-fire-resistive rated:
   1. Manufacturers: The following or equal:
      a. Von Duprin Inc., Model Series 9875L.

C. Material: As scheduled.

2.07 MISCELLANEOUS DOOR HARDWARE

A. Mechanical holders: Foot-operated plunger with instant release by touch of toe and integral spring to keep constant shoe pressure against floor; brass.
   1. Manufacturers: The following or equal:
      a. Glynn-Johnson.

B. Weatherstripping for exterior doors and smoke, light, and sound seals for interior doors.

C. Thresholds: As scheduled, extruded aluminum, maximum 1/2-inch high, maximum slope of 1 foot in 2 feet.
   1. Manufacturers: One of the following or equal:
      a. National Guard Products Inc.
      b. Pemko Mfg. Co.

D. Door bottoms: As scheduled, extruded aluminum with vinyl insert, surface mounted, length equal to door width minus 2 inches, automatic, recessed in bottom of door.
   1. Manufacturers: One of the following or equal:
      a. Pemko.
      b. Reese.

2.08 FINISHES

A. Brass and bronze: BHMA A156.18 626 (US26D), satin chrome.

B. Steel: BHMA A156.18 652 (US26D), satin chrome.

C. Stainless steel: BHMA A156.18 630 (US32D), satin stainless steel.

D. Aluminum: BHMA A156.18 628 (US28).

E. Plastic closer covers: Spray paint to match typical door hardware finish.

F. Metal closer covers: Plate covers to match typical door hardware finish.

G. Electromagnetic hold open devices: Manufacturer's standard brushed zinc finish.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect doors and door frames for damage or defects and examine hardware for compatibility with receiving conditions and suitable to intended use.

B. Verify that required wall backing has been installed.

3.02 INSTALLATION

A. Install finish hardware in accordance with manufacturer's templates and instructions.

B. Accurately and properly fit hardware.

C. Securely fasten fixed parts for smooth, trouble-free, non-binding operation.

D. Fit faces of mortise parts snug and flush.

E. Ensure that operating parts move freely and smoothly without binding, sticking, or excessive clearance.

F. Protection:
   1. Protect door hardware from damage or marring of finish during construction, use strippable coatings, removable tapes, or other acceptable means.
   2. Ensure door hardware displays no evidence of finish paint after final building cleanup.

G. Latch guard and dead bolts: Install so that bolts automatically engage in keeper, whether activated by closer or by manual pressure.

H. Closers:
   1. Mount on opposite sides of corridors or vestibules, except at exterior doors.
   2. Mount for 180-degree swing wherever possible.
   3. Mount with drop plates at narrow top rail doors.
   4. Adjust to operate noiselessly and evenly.
   5. Have closer manufacturer regulate closers prior to final acceptance of project.

I. Thresholds:
   1. Install immediately before inspection for Substantial Completion or protect from heavy traffic damage during construction.
   2. Cope to fit door frame profile and drill to suit required flush bolts and panic bolts.
   3. Unless indicated on the Drawings to be set in grout, set in double bead of sealant, tightly fit at jambs, and make waterproof.
   4. Fasten to concrete slab with 5/16-inch stainless steel flat head countersunk machine screws and concrete anchors at 8-inch centers.

3.03 CONSTRUCTION KEYING

A. Insert construction cores in cylinders of exterior doors, and doors requiring security and access for workman, unless otherwise directed by the Engineer.

3.04 ADJUSTING

A. Examine hardware in place for complete and proper installation. Lubricate bearing surfaces for proper function.

B. Replace, rework or otherwise correct defective door hardware, including incorrect hand or function.

3.05 CLEANING

A. Remove protective materials and devices and thoroughly clean exposed surfaces of hardware.

B. Check for surface damage prior to final cleaning for acceptance of project.

3.06 PERMANENT KEYING

A. Insert permanent cylinders with cores. Inspect each lockset to ensure permanent cylinders with cores are operating satisfactorily.

B. Test keys for proper conformance with keying system.

3.07 HARDWARE LIST

1.

B. HINGES:
   1. H-1: Stanley, FBB199, NRP, US32D.

C. CLOSERS:
   1. C-1: Sargent, EN-351, parallel arm.

D. THRESHOLDS:
   1. T-1: Pemko, 170A.

E. WEATHERSTRIPPING:
   1. W-1: Pemko, 303AS.

F. DOOR BOTTOMS:
   1. D-1: PEMKO, 222AV.

G. EXIT DEVICES:
   1. E-1: Von Duprin, 9875L, mortised type, US32D.

END OF SECTION

SECTION 09910

PAINTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Field applied paints and coatings for normal exposures.
   2. Painting Accessories.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01600 - Product Requirements.
      c. Section 01770 - Closeout Procedures.

1.02 DEFINITIONS

A. Paints: Manufacturer's best ready-mixed coatings, except when field catalyzed, with fully ground pigments having soft paste consistency and capable of being readily and uniformly dispersed to complete homogeneous mixture, having good flowing and brushing properties, and capable of drying or curing free of streaks or sags.

B. Volatile Organic Compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon.

1.03 SUBMITTALS

A. General: Submit as specified in Section 01330.

B. Shop drawings: Include schedule of where and for what use coating materials are proposed in accordance with requirements for Product Data.

C. Product data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips.

D. Samples: Include 8-inch square draw-downs or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number and sheen name and gloss units.

E. Manufacturer's instructions: Submit in accordance with requirements for Product Data. Include:
   1. Special requirements for transportation and storage.
   2. Mixing instructions.
   3. Shelf life.
   4. Pot life of material.
   5. Precautions for applications free of defects.
   6. Surface preparation.
   7. Method of application.
   8. Recommended number of coats.
   9. Recommended thickness of each coat.
   10. Recommended total thickness.
   11. Drying time of each coat, including prime coat.
   12. Required prime coat.
   13. Compatible and non-compatible prime coats.
   14. Recommended thinners, when recommended.
   15. Limits of ambient conditions during and after application.
   16. Time allowed between coats.
   17. Required protection from sun, wind and other conditions.
   18. Touch-up requirements and limitations.

1.04 QUALITY ASSURANCE

A. Products: First line or best grade.

B. Materials for each paint system: By single manufacturer.

C. Applicator qualifications: Applicator of products similar to specified products with minimum 3 years experience.

D. Regulatory requirements: Comply with by using paints that do not exceed governing agency's VOC limits or do not contain lead.

E. Field samples:
   1. Paint 1 complete surface of each color scheme to show colors, finish texture, materials, and workmanship.
   2. Obtain approval before painting other surfaces.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01600.

B. Remove unspecified and unapproved paints from Project site immediately.

C. Deliver containers with labels identifying:
   1. Manufacturer's name.
   2. Brand name.
   3. Product type.
   4. Batch number.
   5. Date of manufacturer.
   6. Expiration date or shelf life.
   7. Color.
   8. Mixing and reducing instructions.

D. Store coatings in well-ventilated facility that provides protection from the sun weather, and fire hazards.
   1. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.

E. Take precautions to prevent fire and spontaneous combustion.

1.06 ENVIRONMENTAL CONDITIONS

A. Surface moisture contents: Do not paint surfaces that exceed manufacturer specified moisture contents, or when not specified by the manufacturer, the following moisture contents:
   1. Plaster and gypsum wallboard: 12 percent.
   2. Masonry, concrete and concrete block: 12 percent.
   3. Interior located wood: 15 percent.
   4. Concrete floors: 7 percent.

B. Do not paint or coat:
   1. Under dusty conditions.
   2. When light on surfaces measures less than 15 foot-candles.
   3. When ambient or surface temperature is less than 50 degrees Fahrenheit or unless manufacturer allow a lower temperature.
   4. When relative humidity is higher than 85 percent, unless manufacturer allows a higher relative humidity.
   5. When surface temperature is less than 5 degrees Fahrenheit above dew point.
   6. When surface temperature exceeds the manufacturer's recommendation.
   7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
   8. Apply clear finishes at minimum 65 degrees Fahrenheit.

C. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.

D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 50 degrees Fahrenheit for 24 hours before, during and 48 hours after application of finishes.

1.07 PROTECTION

A. Protect adjacent surfaces from paint and damage. Repair damage resulting from inadequate or unsuitable protection.

B. Furnish sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being painted and in particular, surfaces within storage and preparation area.

C. Place cotton waste, cloths, and material that may constitute fire hazard in closed metal containers and remove daily from site.

D. Remove electrical plates, surface hardware, fittings and fastenings, prior to painting operations.
   1. Carefully store, clean and replace on completion of painting in each area.

2. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

1.08 EXTRA MATERIALS

A. Extra materials: Deliver as specified in Section 01770. Include minimum 1 gallon of each type and color of coating applied:
   1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
   2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type, and color.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Paints: One of the following or equal:
   1. Carboline: Carboline, St. Louis, MO.
   2. ICI/Devoe: ICI/Devoe/AkzoNobel, Strongsville, OH.
   3. Rustoleum: Rustoleum Corp., Sommerset, NJ.
   4. S/W: Sherwin-Williams Co., Cleveland, OH.
   5. Tnemec: Tnemec Co., Kansas City, MO.

B. Submit requests for substitutions as specified in Section 01600:
   1. Include certified ingredient analyses.
   2. Provide colors that match specified colors.

2.02 PRETREATMENT, PRIMERS, PRIMER-SEALERS, AND WOOD STAIN

A. Aluminum primer: One of following or equal:
   1. Carboline: Carbocrylic 120.
   2. ICI/Devoe: Devflex 4020 DTM.
   3. S/W: DTM Wash Primer.

B. Concrete, porous, filler/primer: One of following or equal:
   1. Carboline: Sanitile 100.
   2. ICI/Devoe: Bloxfill 4000.
   3. S/W: HD Block Filler, B42W46.
   4. Tnemec:
      a. Series 130, Envirofill.
      b. Series 180, Tneme-crete.

C. Concrete, smooth, filler/primer: One of following or equal:
   1. Carboline: Sanitile 100.
   2. Carboline: Carbocrylic 120.
   3. ICI/Devoe:
      a. Bloxfill 4000.
      b. Prep & Prime, Bond Prep 3030.
   4. S/W:
      a. HD Block Filler, B42W46.
      b. Epoxy Masonry Tilt Primer White B42WW49.

5. Tnemec: Series 180, Tneme-Crete.

D. Ferrous metal primer: One of following or equal:
   1. Carboline: Carbocrylic 890.
   2. ICI/Devoe: Barrust 233.
   3. S/W: Macropoxy 646.
   4. Tnemec: Series 104.

E. Galvanized metal surface pretreatment materials: One of following or equal:
   1. Carboline: Surface Cleaner 3.
   2. ICI/Devoe: Devprep 88.

F. Galvanized metal surface primer: One of following or equal:
   1. Carboline: Carbocrylic 890.
   2. ICI/Devoe: Barrust 233.
   3. S/W: Macropoxy 646.
   4. Tnemec: Series 104.

2.03 PAINTS, INTERIOR EXPOSURE

A. Latex, semi-gloss: One of following or equal:
   1. Carboline: Carbocrylic 3359**.**
   2. ICI/Devoe:
      a. Dulux Ultra 1407.
   3. S/W: Promar 200, B77W3402D.

B. Acrylic, semi-gloss: One of following or equal:
   1. Carboline: Carbocrylic 3359.
   2. ICI/Devoe:
      a. Dulux Ultra 1407.
   3. S/W: Promar 200, B77W3402D.
   4. Tnemec: Series 1029, Enduratone.

PART 3 EXECUTION

3.01 INSPECTION

A. Thoroughly examine surfaces scheduled to be painted before starting work.

B. Start painting when unsatisfactory conditions have been corrected.

3.02 SURFACE PREPARATION

A. Prepare surfaces in accordance with paint manufacturer's instructions or when none, the following:
   1. Aluminum:
      a. Remove surface contamination by steam, high-pressure water, or degreasers.
      b. Abrade surface by abrasive blasting, power tool cleaning or hand tool cleaning.
      c. Apply etching primer.
   2. Reinforced concrete panels:

a. Remove dirt, powdery residue, and foreign matter.
b. Paint immediately; both sides when applicable.

3. Canvas and cotton insulation coverings: Remove dirt, grease, and oil.
4. Concrete floors:
   a. Remove contamination, abrasive blast or acid etch and rinse with clear water.
   b. Ensure required acid-alkali balance is achieved. Allow to dry thoroughly.
5. Copper for paint finish:
   a. Remove contamination by steam, high-pressure water, or degreasers.
   b. Abrade surface by abrasive blasting, power tool cleaning or hand tool cleaning.
   c. Apply vinyl etch primer.
6. Copper for oxidized finish:
   a. Remove contamination.
   b. Apply oxidizing solution of copper acetate and ammonium chloride in acetic acid.
   c. Rub on repeatedly for correct effect.
   d. Once attained rinse surfaces well with clear water and allow to dry.
7. Galvanized surfaces:
   a. Remove surface contamination and oils and wash with degreasers.
   b. Apply coat of etching type primer.
8. Zinc coated surfaces: Remove surface contamination and oils and prepare for priming in accordance with metal manufacturer's recommendations.
9. Concrete and concrete masonry:
   a. Remove dirt, loose mortar, scale, powder and other foreign matter.
   b. Remove oil and grease with solution of tri-sodium phosphate.
   c. Remove stains caused by weathering of corroding metals with solution of sodium metasilicate.
   d. Rinse well and allow to thoroughly dry.
   e. Spot prime exposed metal with alkyd primer.
10. Unprimed steel and iron: Remove grease, rust, scale, dirt and dust by wire brushing, sandblasting or other necessary method.
11. Shop primed steel:
    a. Sand and scrape to remove loose primer and rust.
    b. Feather out edges to make touch-up patches inconspicuous.
    c. Clean surfaces.
    d. Prime bare steel surfaces.

3.03 APPLICATION

A. Apply each coat at proper consistency.

B. Tint each coat of paint slightly darker than preceding coat.

C. Sand lightly between coats to achieve required finish.

D. Do not apply finishes on surfaces that are not sufficiently dry.

E. Allow each coat of finish to dry before following coat is applied, unless directed otherwise by manufacturer.

3.04 MECHANICAL AND ELECTRICAL EQUIPMENT

A. Identify equipment, ducting, piping, and conduit in accordance with Related Sections.

B. Remove grilles, covers, and access panels for mechanical and electrical system from location and paint separately.

C. Finish paint primed equipment with color selected by the Engineer.

D. Prime and paint insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are plated or covered with prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when painted over or spattered.

F. Paint interior surfaces of air ducts, convector, and baseboard heating cabinets that are visible through grilles and louvers with 1 coat of flat black paint, to limit of sight line.

G. Paint dampers exposed immediately behind louvers, grilles, convector, and baseboard cabinets to match face panels.

H. Paint exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.

I. Paint both sides and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, exposed ductwork, and apply color banding and identification, such as flow arrows, naming and numbering, in accordance with the Contract Documents.

3.05 SURFACES NOT REQUIRING FINISHING

A. Stainless steel, brass, bronze, copper, monel, chromium, anodized aluminum: Specially finished articles such as porcelain enamel, plastic coated fabrics, and baked enamel.

B. Finished products such as ceramic tile, windows, glass, brick, resilient flooring, acoustical tiles, board and metal tees; other architectural features, such as finish hardware, furnished in aluminum, bronze or plated ferrous metal, prefinished panels, or other items that are installed prefinished.

C. Items completely finished at factory, such as preformed metal roof and wall panels, aluminum frames, toilet compartments, sound control panels, acoustical tiles, shower compartments, folding partition, and flagpole.

3.06 CLEANING

A. As work proceeds and upon completion, promptly remove paint where spilled, splashed, or spattered.

B. During progress of work, keep premises free from unnecessary accumulation of tools, equipment, surplus materials, and debris.

C. Upon completion of work, leave premises neat and clean.

3.07 INTERIOR PAINT SCHEDULE

A. Aluminum: 2 coats of following finish paints over specified primer:
   1. Acrylic, semi-gloss:
      a. Surfaces not scheduled otherwise.

B. Metal, galvanized: 2 coats of following finish paints over specified primer:
   1. Acrylic, semi-gloss:
      a. Surfaces not scheduled otherwise.

C. Metal, non-galvanized ferrous: 2 coats of following finish paints over specified primer:
   1. Acrylic, semi-gloss:
   2. Surfaces not scheduled otherwise.

END OF SECTION

SECTION 09960

COATINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Field applied coatings.

B. Related Sections:
   1. Section 01330 - Submittal Procedures.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
   2. D 4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
   3. D 4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
   4. D 4541 - Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers.

B. NACE International, The Corrosion Society (NACE):
   1. RPO188-99 - Discontinuity (Holiday) Testing of Protective Coatings.

C. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

E. SSPC - Society for Protective Coatings:
   1. SP1 - Solvent Cleaning.
   2. SP2 - Hand Tool Cleaning.
   3. SP3 - Power Tool Cleaning.
   4. SP5 - White Metal Blast Cleaning.
   5. SP6 - Commercial Blast Cleaning.
   6. SP7 - Brush-Off Blast Cleaning.
   7. SP10 - Near-White Blast Cleaning.
   8. SP 11 - Power Tool Cleaning to Bare Metal.
   9. SP 12 - Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating.

F. Underwriters' Laboratory, Inc. (UL):
   1. 3P83 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. Submerged metal: Steel or iron surfaces below tops of channel or structure walls which will contain water even when above expected water level.

B. Submerged concrete and masonry surfaces: Surfaces which are or will be:
   1. Underwater.
   2. In structures which normally contain water.
   3. Below tops of walls of water containing structures.

C. Exposed surface: Any metal or concrete surface, indoors or outdoors that is exposed to view.

D. Dry film thickness (DFT): Thickness of fully cured coating, measured in mils.

E. Volatile organic compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon, as determined by EPA Method 24.

F. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.

G. Where SSPC surface preparation standards are specified or implied for ductile iron pipe or fittings, the equivalent NAPF surface preparation standard shall be substituted for the SSPC standard.

1.04 PERFORMANCE REQUIREMENTS

A. Coating materials for concrete and metal surfaces shall be especially adapted for use in wastewater treatment plants.

B. Coating materials used in conjunction with potable water supply systems shall be certified to NSF 61 or UL 3P83.

1.05 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Shop drawings: Include schedule of where and for what use coating materials are proposed in accordance with requirements for Product Data.

C. Product data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips:
   1. Regulatory requirements: Submit data concerning the following:
      a. Volatile organic compound limitations.
      b. Coatings containing lead compounds and PCBs.
      c. Abrasives and abrasive blast cleaning techniques, and disposal.
      d. NSF or UL certification of coatings for use in potable water supply systems.

D. Samples: Include 8-inch square drawdowns or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number and sheen name and gloss units.

E. Certificates: Submit in accordance with requirements for Product Data.

F. Manufacturer's instructions: Include the following:
   1. Special requirements for transportation and storage.
   2. Mixing instructions.
   3. Shelf life.
   4. Pot life of material.
   5. Precautions for applications free of defects.
   6. Surface preparation.
   7. Method of application.
   8. Recommended number of coats.
   9. Recommended dry film thickness (DFT) of each coat.
   10. Recommended total dry film thickness (DFT).
   11. Drying time of each coat, including prime coat.
   12. Required prime coat.
   13. Compatible and non-compatible prime coats.
   14. Recommended thinners, when recommended.
   15. Limits of ambient conditions during and after application.
   16. Time allowed between coats (minimum and maximum).
   17. Required protection from sun, wind and other conditions.
   18. Touch-up requirements and limitations.

G. Manufacturer's representative’s field reports.

H. Operations and maintenance data: Submit as specified in Section 01770.
   1. Reports on visits to project site to view and approve surface preparation of structures to be coated.
   2. Reports on visits to project site to observe and approve coating application procedures.
   3. Reports on visits to coating plants to observe and approve surface preparation and coating application on items that are “shop coated.”

I. Quality assurance submittals:
   1. Quality assurance plan.
   2. Qualifications of coating applicator including List of Similar Projects.

1.06 QUALITY ASSURANCE

A. Applicator qualifications:
   1. Minimum of 5 years experience applying specified type or types of coatings under conditions similar to those of the Work:
      a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 2 years.
   2. Manufacturer approved applicator when manufacturer has approved applicator program.
   3. Approved and licensed by polymorphic polyester resin manufacturer to apply polymorphic polyester resin coating system.
   4. Approved and licensed by elastomeric polyurethane (100 percent solids) manufacturer to apply 100 percent solids elastomeric polyurethane system.

5. Applicator of off-site application of coal tar epoxy shall have successfully applied coal tar epoxy on similar surfaces in material, size, and complexity as on the Project.

B. Regulatory requirements: Comply with governing agencies regulations by using coatings that do not exceed permissible volatile organic compound limits and do not contain lead:
   1. Do not use coal tar epoxy in contact with drinking water.

C. Certification: Certify that applicable pigments are resistant to discoloration or deterioration when exposed to hydrogen sulfide and other sewage gases and product data fails to designate coating as "fume resistant."

D. Field samples: Prepare and coat a minimum 100 square foot area between corners or limits such as control or construction joints of each system. Approved field sample may be part of Work.

E. Pre-installation conference: Conduct as specified in Section 01312.

F. Compatibility of coatings: Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

G. Services of coating manufacturers representative: Arrange for coating manufacturers representative to attend pre-installation conferences. Make periodic visits to the project site to provide consultation and inspection services during surface preparation and application of coatings, and to make visits to coating plants to observe and approve surface preparation procedures and coating application of items to be “shop primed and coated”.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with Section 01600.

B. Remove unspecified and unapproved paints from Project site immediately.

C. Deliver containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.

D. Store coatings in well-ventilated facility that provides protection form the sun weather, and fire hazards. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.

E. Take precautions to prevent fire and spontaneous combustion.

1.08 PROJECT CONDITIONS

A. Surface moisture contents: Do not coat surfaces that exceed manufacturer specified moisture contents, or when not specified by the manufacturer, the following moisture contents:
   1. Plaster and gypsum wallboard: 12 percent.
   2. Masonry, concrete and concrete block: 12 percent.
   3. Interior located wood: 15 percent.

4. Concrete floors: 7 percent.

B. Do not apply coatings:
   1. Under dusty conditions, unless tenting, covers, or other such protection is provided for structures to be coated.
   2. When light on surfaces measures less than 15 foot-candles.
   3. When ambient or surface temperature is less than 50 degrees Fahrenheit unless manufacturer allows a lower temperature.
   4. When relative humidity is higher than 85 percent.
   5. When surface temperature is less than 5 degrees Fahrenheit above dew point.
   6. When surface temperature exceeds the manufacturer's recommendation.
   7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
   8. Apply clear finishes at minimum 65 degrees Fahrenheit.

C. Provide fans, heating devices, dehumidifiers, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.

D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 50 degrees Fahrenheit for 24 hours before, during and 48 hours after application of finishes.

1.09 SEQUENCING AND SCHEDULING

A. Sequence and schedule: As specified in Sections 01352 and 01140.

1.10 MAINTENANCE

A. Extra materials: Deliver in accordance with Section 01770. Include minimum 1 gallon of each type and color of coating applied.
   1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
   2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type and color.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Special coatings: One of the following or equal:
   1. Ameron: Ameron International, Brea, CA.
   2. Carboline: Carboline, St. Louis, MO.
   3. Devoe: Devoe Coatings, Louisville, KY.
   4. Dudick: Dudick, Inc., Streetsboro, OH.
   5. Enduraflex: Global Eco Technologies, Pittsburg, CA.
   6. IET: Integrated Environmental Technologies, Santa Barbara, CA.
   7. PPC: Polymorphic Polymers Corp., N. Miami, FL.
   8. S-W: Sherwin-Williams Co., Cleveland, OH.
   9. Tnemec: Tnemec Co., Kansas City, MO.

10. The Euclid Chemical Co., Cleveland, OH.

2.02 PREPARATION AND PRETREATMENT MATERIALS

A. Metal pretreatment: As manufactured by one of the following or equal:
   1. Ameron: Galvaprep.
   2. International: Galvaprep 5 or Alumiprep 33.
   3. S-W: P60G2, Wash Primer.
   4. Tnemec: Series N69 Hi-Build Epoxoline II.

B. Surface cleaner and degreaser: As manufactured by one of the following or equal:
   1. Carboline Surface Cleaner No. 3.
   2. Devoe: Devprep 88.
   3. S-W: Clean and Etch.
   4. Euclid: EUCO concrete floor cleaner.

2.03 COATING MATERIALS

A. Alkali resistant bitumastic: As manufactured by one of the following or equal:
   1. Carboline: Bitumastic Super Service Black.
   2. S-W: Corothane I Coal Tar, B65B11.
   3. Tnemec: 46-465.
   4. Wasser: MC-Tar.

B. Wax coating: As manufactured by one of the following or equal:
   1. Sanchem: No-Ox-Id A special.

C. High solids epoxy primer not less than 80 percent solids by volume: As manufactured by one of the following or equal:
   1. Ameron: Amerlock 400.
   2. Carboline: Carbogard 891.
   3. Devoe: Bar Rust 233H.
   4. S-W: Macropoxy HS (Macropoxy 646 if top coated with polyurethane).
   5. Tnemec: Series N69 Hi-Build Epoxoline II.
   6. Euclid: Duraprime WB.

D. High solids epoxy not less than 80 percent solids by volume: As manufactured by one of the following or equal:
   1. Ameron: Amerlock 400.
   2. Carboline: Super Hi-Gard 891.
   3. Devoe: Bar Rust 233H.
   4. S-W: Macropoxy HS (Macropoxy 646 if top coated with polyurethane).
   5. Tnemec:
      a. Series N69 Hi-Build Epoxoline II.
   6. Euclid: Duraprime WB.

E. Aliphatic or aliphatic-acrylic polyurethane: As manufactured by one of the following or equal:
   1. Ameron: Amercoat 450HS.
   2. Carboline: Carbothane 134HG.
   3. Devoe: Devthane 379.
   4. S-W: High Solids Polyurethane.
   5. Tnemec: Series 1075 Endura-Shield II.

6. Euclid: Dural 1004-C.

F. Asphalt varnish: AWWA C 500.

G. Vinyl ester: Glassmat reinforced, total system 125 mils DFT. As manufactured by one of the following or equal:
   1. Carboline: Semstone 870.
   2. Tnemec: Series 252 SC.
   3. Dudick: Protecto-Line 800.
   4. S/W: Cor Cote VEN FF.
   5. Euclid: Dural 360.

H. Elastomeric polyurethane, 100 Percent Solids, ASTM D16, Type V, (Urethane P): As manufactured by one of the following or equal:
   1. Endura-Flex: Endura-Flex EF-1988.
   2. Tnemec: Series 406 Elasto-Shield.
   3. S/W: Sher Flex.
   4. Euclid: Duraldeck System.

O. Concrete floor coatings: As manufactured by one of the following or equal:
   1. Carboline: Semstone 145.
   2. Devoe: Derran 124.
   3. Dudick: Protecto Coat 100XT-SL.
   4. Tnemec: Series 239/282.
   5. S/W: Armorseal 650 SL.
   6. Euclid: Duraltex or Eucopoxy Tufcoat DBS.

I. Coal tar epoxy: As manufactured by one of the following or equal:
   1. S-W: Tar Guard
   2. Carboline: 300-M, Bitumastic.

PART 3 EXECUTION

3.01 GENERAL PROTECTION

A. Protect adjacent surfaces from coatings and damage. Repair damage resulting from inadequate or unsuitable protection:

B. Protect adjacent surfaces not to be coated from spatter and droppings with drop cloths and other coverings:
   1. Mask off surfaces of items not to be coated or remove items from area.

C. Furnish sufficient drop cloths, shields and protective equipment to prevent spray or droppings from fouling surfaces not being coated and in particular, surfaces within storage and preparation area.

D. Place cotton waste, cloths and material which may constitute fire hazard in closed metal containers and remove daily from site.

E. Remove electrical plates, surface hardware, fittings and fastenings, prior to application of coating operations. Carefully store, clean and replace on completion

of coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

3.02 GENERAL PREPARATION

A. Prepare surfaces in accordance with coating manufacturer's instructions, unless more stringent requirements are specified in this Specification.

B. Protect following surfaces from abrasive blasting by masking, or other means:
   1. Threaded portions of valve and gate stems.
   2. Machined surfaces for sliding contact.
   3. Surfaces to be assembled against gaskets.
   4. Surfaces of shafting on which sprockets are to fit.
   5. Surfaces of shafting on which bearings are to fit.
   6. Machined surfaces of bronze trim, including those slide gates.
   7. Cadmium-plated items except cadmium-plated, zinc-plated, or sherardized fasteners used in assembly of equipment requiring abrasive blasting.
   8. Galvanized items, unless scheduled to be coated.

C. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by entering sand or dust.

D. Concrete:
   1. Allow new concrete to cure for minimum of 28 days before coating.
   2. Clean concrete surfaces of dust, mortar, fins, loose concrete particles, form release materials, oil, and grease. Fill voids so that surface is smooth. Etch or brush off-blast clean in accordance with SSPC SP-7 to provide surface profile similar to 60 grit sandpaper, or as recommended by coating manufacturer.

E. Ferrous metal surfaces:
   1. Remove grease and oil in accordance with SSPC SP-1.
   2. Remove rust, scale, and welding slag and spatter, and prepare surfaces in accordance with appropriate SSPC standard as specified herein.
   3. Abrasive blast surfaces prior to coating.
   4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast surfaces again to remove rust and discoloration.
   5. When metal surfaces are exposed because of coating damage, abrasive blast surfaces before touching-up.

F. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC SP-10, unless blasting may damage adjacent surfaces, prohibited or specified otherwise. Where not possible to abrasive blast, power tool clean surfaces in accordance with SSPC SP-3.

G. Ferrous metal surfaces to be submerged: Unless specified otherwise, abrasive blast in accordance with SSPC SP-5 to clean and provide roughened surface profile of not less than 2 mils and not more than 4 mils in depth when measured with Elcometer 123, or as recommended by the coating manufacturer.

H. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

I. Sherardized, aluminum, copper, and bronze surfaces: Prepare in accordance with coating manufacturer's instructions.

J. Galvanized surface:
   1. Degrease or solvent clean to remove oily residue.
   2. Power tool or hand tool clean or whip abrasive blast.
   3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded physically, such as bolts, nuts, or preformed channels.

K. Shop primed metal:
   1. Certify that primers applied to metal surfaces in the shop are compatible with coatings to be applied over such primers in the field.
   2. Remove shop primer from metal to be submerged by abrasive blasting in accordance with SSPC SP-10, unless greater degree of surface preparation is required by coating manufacturer’s representative.
   3. Correct abraded, scratched or otherwise damaged areas of shop prime coat by sanding or abrasive blasting in accordance with SSPC SP-6.
   4. When entire shop priming fails or has weathered excessively, or when recommended by coating manufacturer’s representative, abrasive blast shop prime coat to remove entire coat and prepare surface in accordance with SSPC SP-10.
   5. When incorrect prime coat is applied, remove incorrect prime coat by abrasive blasting in accordance with SSPC SP-10.
   6. When prime coat not authorized by ENGINEER is applied, remove unauthorized prime coat by abrasive blasting in accordance with SSPC SP-10.
   7. Shop Applied Bituminous Paint or Asphalt Varnish: Abrasive blast clean shop applied bituminous paint or asphalt varnish from surfaces scheduled to receive non-bituminous coatings.

L. Abrasive blast cadmium-plated, zinc-plated, or sherardized fasteners in same manner as unprotected metal when used in assembly of equipment designated for abrasive blasting.

M. Abrasive blast components to be attached to surfaces which cannot be abrasive blasted before components are attached.

N. Grind sharp edges to approximately 1/16 inch radius before abrasive blast cleaning.

O. Remove and grind smooth all excessive weld material and weld spatter before blast cleaning.

P. PVC and FRP surfaces:
   1. Prepare surfaces to be coated by light sanding and wipe-down with clean cloths, or by solvent cleaning in strict accordance with coating manufacturer's instructions.

Q. Cleaning of previously coated surfaces:
   1. Utilize cleaning agent to remove soluble salts such as chlorides and sulfates from concrete and metal surfaces:
      a. Cleaning Agent: Biodegradable non-flammable and containing no volatile organic compounds.
      b. Manufacturer: Chlor-Rid International, Inc., or accepted equal.

2. Cleaning of surfaces utilizing the decontamination cleaning agent may be accomplished in conjunction with abrasive blast cleaning, high pressure, washing, or hand washing as approved by the coating manufacturer's representative and the ENGINEER.
3. Test cleaned surfaces in accordance with the cleaning agent manufacturer's instructions to ensure all soluble salts have been removed. Additional cleaning shall be carried out as necessary.
4. Final surface preparation prior to application of new coating system shall be made in strict accordance with coating manufacturer's printed instructions.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT

A. Identify equipment, ducting, piping, and conduit in accordance with Section 15075 and Section 16075.

B. Remove grilles, covers and access panels for mechanical and electrical system from location and coat separately.

C. Finish coat primed equipment with color selected by the ENGINEER.

D. Prime and coat insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars and supports, except where items are plated or covered with prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Coat interior surfaces of air ducts, convector and baseboard heating cabinets that are visible through grilles and louvers with 1 coat of flat black paint, to limit of sight line.

G. Coat dampers exposed immediately behind louvers, grilles, convector and baseboard cabinets to match face panels.

H. Coat exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.

I. Coat both sides and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit and exposed ductwork and apply color banding and identification, such as flow arrows, naming and numbering, in accordance with Divisions 15 and 16.

3.04 GENERAL APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Coat metal unless specified otherwise:
1. Aboveground piping to be coated shall be empty of contents during application of coatings.

C. Verify metal surface preparation immediately before applying coating in accordance with SSPC Pictorial Surface Preparation Standard.

D. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

E. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

F. Prime shop primed metal surfaces. Spot prime exposed metal of shop primed surfaces before applying primer over entire surface.

G. Apply minimum number of specified coats.

H. Apply coats to thicknesses specified, especially at edges and corners.

I. Apply additional coats when necessary to achieve specified thicknesses.

J. Coat surfaces without drops, ridges, waves, holidays, laps, or brush marks.

K. Remove spatter and droppings after completion of coating.

L. When multiple coats of same material are specified, tint prime coat and intermediate coats with suitable pigment to distinguish each coat.

M. Dust coatings between coats. Lightly sand and dust surfaces to receive high gloss finishes, unless instructed otherwise by coating manufacturer.

N. Apply coating by brush, roller, trowel, or spray, unless particular method of application is required by coating manufacturer's instructions or these Specifications.

O. Spray application:
   1. Stripe coat edges by brush before beginning spray application, as necessary, to ensure specified coating thickness along edges.
   2. When using spray application, apply coating to thickness not greater than that recommended in coating manufacturer's instructions for brush coat application.
   3. Use airless spray method, unless air spray method is required by coating manufacturer's instruction or these Specifications.
   4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist or spray.

P. Drying and recoating:
   1. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
   2. Limit drying time to that required by these Specifications or coating manufacturer's instructions.
   3. Do not allow excessive drying time or exposure which may impair bond between coats.
   4. Recoat epoxies within time limits recommended by coating manufacturer.

5. When time limits are exceeded, abrasive blast clean prior to applying another coat.
6. When limitation on time between abrasive blasting and coating cannot be met before attachment of components to surfaces which cannot be abrasive blasted, coat components before attachment.
7. Ensure primer and intermediate coats of coating are unscarred and completely integral at time of application of each succeeding coat.
8. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
9. Leave no holidays.
10. Sand and recoat scratched, contaminated, or otherwise damaged coating surfaces so damages are invisible to naked eye.

Q. Concrete:
1. Apply first coat (primer) only when surface temperature of concrete is decreasing in order to eliminate effects of off-gassing on coating.

3.05 ALKALI RESISTANT BITUMASTIC

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements.

B. Application:
1. Apply in Accordance with General Application Requirements and as Follows:
a. Apply at least 2 coats, 8 to 14 mils dry film thickness each.

3.06 WAX COATING

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements.

B. Application:
1. Apply in Accordance with General Application Requirements and as follows:
a. Apply at least 1/32-inch thick coat with 2-inch or shorter bristle brush.
b. Thoroughly rub coating into metal surface with canvas covered wood block or canvas glove.

3.07 HIGH SOLIDS EPOXY SYSTEM

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements and as follows:
a. Abrasive blast ferrous metal surfaces to be submerged at jobsite in accordance with SSPC SP-5 prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-10.
b. Abrasive blast non-submerged ferrous metal surfaces at jobsite in accordance with SSPC SP-10, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-6.
c. Abrasive blast clean ductile iron surfaces in accordance with SSPC SP-7.

B. Application:
1. Apply coatings in accordance with general application requirements and as follows:
a. Apply minimum 2-coat system with minimum total dry film thickness (DFT) of 12 mils.
b. Recoat or apply succeeding epoxy coats within time limits recommended by manufacturer. Prepare surfaces for recoating in accordance with manufacturer's instructions.
c. Coat metal to be submerged before installation when necessary, to obtain acceptable finish and to prevent damage to other surfaces.
d. Coat entire surface of support brackets, stem guides, pipe clips, fasteners, and other metal devices bolted to concrete.
e. Coat surface of items to be exposed and adjacent 1 inch to be concealed when embedded in concrete or masonry.

3.08 HIGH SOLIDS EPOXY AND POLYURETHANE COATING SYSTEM

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements and as follows:
a. Prepare concrete surfaces in accordance with general preparation requirements.
b. Touch up shop primed steel and miscellaneous iron.
c. Abrasive blast ferrous metal surfaces at jobsite in accordance with SSPC SP-6, Commercial Blast Cleaning, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-6.
d. Degrease or solvent clean, whip abrasive blast, power tool, or hand tool clean galvanized metal surfaces.
e. Lightly sand fiberglass and poly vinyl chloride (PVC) pipe to be coated and wipe clean with dry cloths, or solvent clean in accordance with coating manufacturer's instructions.
f. Abrasive blast clean ductile iron surfaces.

B. Application:
1. Apply coatings in accordance with general application requirements and as follows:
a. Apply 3 Coat System Consisting of:
1) Primer: 4 to 5 mils dry film thickness high solids epoxy primer.
2) Intermediate Coat: 4 to 5 mils dry film thickness high solids epoxy intermediate coat.
3) Top Coat: 2.5 to 3.5 mils dry film thickness aliphatic or aliphatic-acrylic polyurethane topcoat.
2. Recoat or apply succeeding epoxy coats within 30 days or within time limits recommended by manufacturer, whichever is shorter. Prepare surfaces for recoating in accordance with manufacturer's instructions.
3. For fiberglass and PVC pipe, apply 1 coat high solids epoxy (4 to 5 mils DFT) and 2 coats aliphatic or aliphatic-acrylic polyurethane.

3.09 ASPHALT VARNISH

A. Preparation:
   1. Prepare surfaces in accordance with general preparation requirements.

B. Application:
   1. Apply coatings in accordance with general application requirements and as follows:
      a. Apply minimum 2 coats.

3.10 VINYL ESTER

A. Preparation:
   1. Prepare surfaces in accordance with coating manufacturer's recommendations and as directed and approved by coating manufacturer's representative.

B. Application:
   1. Apply prime coat, as required by coating manufacturer, base coat, glass mat, and topcoat to total dry film thickness of 125 mils minimum:
      a. Final topcoat on floors shall include non-skid surface, applied in accordance with manufacturer's instructions.
   2. Perform holiday detection test over 100 percent of coated surface areas to ensure pinhole free finished coating system.
   3. All work shall be accomplished in strict accordance with coating manufacturer's instructions and under direction of coating manufacturer's representative.

3.11 ELASTOMERIC POLYURETHANE (100 PERCENT SOLIDS)

A. Preparation:
   1. Prepare surfaces in strict accordance with coating manufacturer's instructions and as directed and approved by coating manufacturer's representative.

B. Application:
   1. Apply epoxy primer at DFT of 1 to 2 mils, in strict accordance with manufacturer's instructions.
   2. Apply polyurethane coating at minimum total DFT as follows:
      a. Steel: 60 mils DFT.
      b. Ductile iron and ductile iron pipe coating and lining: 30 mils DFT.
      c. Concrete: 120 mils DFT.
      d. Or as recommended by the coating manufacturer and accepted by the ENGINEER.
   3. For concrete application, provide saw cutting for coating terminations in strict accordance with manufacturer's instructions.

3.12 CONCRETE FLOOR COATINGS

A. Preparation:
   1. Prepare surfaces in accordance with general application requirements and in strict a accordance with coating manufacturer’s instructions.

B. Application:
   1. Apply primer if required by coating manufacturer.

2. Apply 1 or more coats as recommended by coating manufacturer to receive a minimum total dry film thickness of 25 mils, color as selected by OWNER.
3. Final topcoat shall include non-skid surface, applied in strict accordance with coating manufacturer's instructions.

3.13 COAL TAR EPOXY

A. Preparation:
   1. Prepare surfaces in accordance with general preparation requirements and as follows:
      a. Abrasive blast iron or steel surfaces to be coated in accordance with SSPC SP-6/NACE 3. Prepare metal surfaces to be coated with coal tar epoxy in accordance with epoxy manufacturer's instructions.

B. Application:
   1. Apply coatings in accordance with general application requirements and as follows:
      a. Apply 2 coats of 8 mils each for a total 16 mils dry film thickness.
      b. Apply coal tar epoxy on blasted steel on same day that steel is blasted.
      c. Apply succeeding coats over previous coat as soon as application does not cause sagging, within the following times, or as recommended by the coating manufacturer, whichever is sooner.

3.14 FIELD QUALITY CONTROL

A. Each coat will be inspected. Strip and remove defective coats, prepare surfaces and recoat. When approved, apply next coat.
   1. Provide all inspection equipment required.

B. Control and check wet and dry film thicknesses and integrity of coatings.

C. Measure dry film thickness with calibrated thickness gauge.

D. Dry film thicknesses on ferrous-based substrates may be checked with Elcometer Type 1 Magnetic Pull-Off Gage or Positector 6000.

E. Verify coat integrity with low-voltage holiday detector in accordance with NACE RP0188-99. Allow ENGINEER to use detector for additional checking.

F. Check wet film thickness before coal tar epoxy coating cures on concrete or non-ferrous metal substrates.

G. Arrange for services of coating manufacturer's field representative to provide periodic field consultation and inspection services to ensure proper surface preparation of facilities and items to be coated, and to ensure proper application and curing:
   1. Notify ENGINEER 24 hours in advance of each visit by coating manufacturer's representative.
   2. Provide ENGINEER with a written report by coating manufacturer's representative within 48 hours following each visit.

3.15 SCHEDULE OF ITEMS NOT REQUIRING COATING

A. General: Unless specified otherwise, the following items do not require coating:
   1. Items that have received final coat at factory and not listed to receive coating in field.
   2. Aluminum, brass, bronze, copper, plastic (except PVC pipe), rubber, stainless steel, chrome, Everdur, or lead.
   3. Buried or encased electrical conduit.
   4. Exterior Concrete.
   5. Galvanized roof decking, electrical conduits, pipe trays, cable trays, and other items:
      a. Areas on galvanized items or parts where galvanizing has been damaged during handling or construction shall be repaired as follows:
         1) Clean damaged areas by SSPC SP-1, SP-2, SP-3, or SP-7 as required.
         2) Apply 2 coats of a cold galvanizing zinc compound such as ZRC World Wide Inovatie Zinc Technologies of Mansfield, MA or accepted equal, in strict accordance with manufacturer's instructions.
   6. Grease fittings.
   7. Fiberglass ducting or tanks in concealed locations.
   8. Structural Steel to be encased in concrete or masonry.

3.16 SCHEDULE OF SURFACES TO BE COATED IN THE FIELD

A. In general, apply coatings to steel, iron, galvanized surfaces, and wood surfaces unless specified or otherwise indicated on the Drawings. Coat concrete surfaces and anodized aluminum only when specified or indicated on the Drawings

B. Following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Verify questionable surfaces.

C. Concrete:
   1. High solids epoxy:
      a. Safety markings.
   2. Vinyl ester:
      a. Secondary containment: All concrete surfaces inside chemical containment areas including inside wall surfaces, top of wall surfaces, sump area, tank fill area, including equipment pads, and tank pads.
      b. Chemical metering pump areas: Concrete slab, equipment pads, inside face of containment curb, top of curb, and pump area walls within the containment curb to a height of 6 inches above the floor.
      c. Suitable for 72 hours immersion in:
         1) 39 percent to 47 percent ferric chloride solution.
         2) 40 percent active polymer.
      d. Concrete floor surfaces in chemical containment areas shall have a non-skid surface.
   3. Secondary Clarifier
      a. Sewer Shield 150
      b. Sauereisen Sewer Guard 210X
      c. Surface preparation: sand blast to expose aggregate (80 grit)
      d. Apply in two coats, 125 mil thickness total

D. Metals:
   1. Alkali resistant bitumastic:
      a. Aluminum surfaces to be placed in contact with wood, concrete, or masonry.
   2. Wax coating:
      a. Sliding faces of sluice and slide gates and threaded portions of gate stems.
   3. Epoxy and polyurethane system: Interior and exterior non-immersed ferrous metal surfaces including:
      a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
      b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
      c. Motors and motor accessory equipment.
      d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
      e. Valve and gate operators and stands.
      f. Structural steel including galvanized structural steel and exposed underside of metal roof deck.
      g. Crane and hoist rails.
      h. Exterior of tanks and other containment vessels.
      i. Mechanical equipment supports, drive units, and accessories.
      j. Pumps not submerged.
      k. Degritters, grit classifiers, frames, supports, and associated equipment.
      l. Other miscellaneous metals.
   4. High solids epoxy system:
      a. Field priming of ferrous metal surfaces with defective shop prime coat where no other prime coat is specified; for non-immersion service.
      b. Bell rings, underside of manhole covers and frames.
      c. Sump pumps and grit pumps, including underside of base plates and submerged suction and discharge piping.
      d. Submerged piping.
      e. Submerged pipe supports and hangers.
      f. Exterior of submerged piping and valves other than stainless steel or PVC piping.
      g. Stem guides.
      h. Other submerged iron and steel metal unless specified otherwise.
      i. Aboveground low pressure air pipe, fittings and couplings.
   5. Asphalt varnish:
      a. Underground valves and valve boxes.
   6. Protective coal tar:
      a. Underground pipe flanges, excluding pipe, corrugated metal pipe couplings, flexible pipe couplings and miscellaneous underground metals not otherwise specified to receive another protective coating.
   7. Coal tar epoxy:
      a. Underground Low Pressure Air Pipe, fittings and couplings.
   8. Elastomeric polyurethane (100% Solids).

E. Concrete masonry block:
   1. Water repellant per Section 07190.

K. Fiberglass and PVC pipe surfaces:

1. Epoxy and polyurethane:
    a. Exterior of fiberglass ducting and fan housings.
    b. Fiberglass exposed to sunlight.
    c. All exposed PVC or CPVC piping, valves, and fittings, except interior exposed double contained piping.

END OF SECTION

SECTION 10400

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic and metal signs for building and site use.

1.02 SUBMITTALS

A. Product data:

B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.

C. Samples: Include actual materials.

D. Manufacturer's installation instructions.

1.03 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.

C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

PART 2 PRODUCTS

2.01 PLASTIC SIGNAGE SYSTEM

A. Manufacturers:
   1. One of the following or equal:
      a. Best Manufacturing Sign Systems, Montrose, CO; System 900013.
      b. Andco Industries Corp., Greensboro, NC; equivalent product.
      c. Vomar Products, Inc., Sepulveda, CA; equivalent product.

B. Attachment:
   1. Vinyl tape, self-adhering.

C. Lettering:
   1. Helvetica medium, 3/4 inches high.

D. Material for interior use:
   1. Plastic 1/8-inch thick raised letters.

E. Material for exterior use:
   1. Fiberglass 1/4 inch thick with high gloss finish, raised letters, blasted from single piece of fiberglass for integral letter and background.
   2. No adhesive as mechanical fastening of letters shall be allowed.

F. Colors:
   1. As selected by Engineer from manufacturer's standard colors.

G. See Schedule A for specific sign size, location, text, pictogram, and quantity.

2.02 METAL SAFETY SIGNS

A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
   1. Seton Name Plate Co., Branford, Connecticut, Special Wording.
   2. Emedco, Buffalo, New York.

B. Danger sign colors:
   1. Background: White.
   2. Heading: White lettering on red oval with white border in black rectangular panel.
   3. Message: Black lettering on white.
   4. Size: As scheduled.

C. Caution sign colors:
   1. Background: Yellow.
   2. Heading: Yellow lettering on black rectangular panel.
   3. Message: Black lettering on yellow.
   4. Size: As scheduled.

D. Safety instruction signs:
   1. Background: White.
   2. Heading: White lettering on green rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

E. Warning sign colors:
   1. Background: Orange.
   2. Heading: Black lettering on orange diamond in black rectangular panel.
   3. Message: Flack lettering on orange.
   4. Size: As scheduled.

F. Notice information signs:
   1. Background: White.
   2. Heading: White lettering on blue rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

G. Fasteners: Round head stainless steel bolts or screws.

H. See Schedule B for specific sign size, location, text, and quantity.

I. Provide 10 additional metal safety signs with text to be determined.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect adjacent surfaces which may be damaged by installation of signs.

B. Prepare substrates in accordance with sign manufacturer's instructions.

C. Remove scale, dirt, grease, and other contaminates from substrates.

3.02 INSTALLATION

A. Install signs in accordance with sign manufacturer's instructions.

B. Fasten signs securely in level, plumb, and true to plane positions.

C. Install signs as approved by Owner and Engineer in the field.

3.03 SCHEDULES

A. Plastic Signage System Schedule.

B. Metal Safety Sign Schedule.

END OF SECTION

SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE

A. Room Names:
   1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
   2. Height: 60 inches above floor to center or sign.
   3. Size: 6 inches square.
   4. Colors: As selected by Engineer.
   5. Text: **Sign per door of following rooms:**

      ELECTRICAL ROOM (3 total required)
      PROCESS ROOM

B. Fire Extinguishers:
   1. Location: Adjacent to fire extinguishers.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: White letters on OSHA Red background.
   5. Text: FIRE EXTINGUISHER.

C. Nonpotable Water:
   1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: CAUTION
   5. Text: IMPURE WATER
      DO NOT DRINK

D. No Pedestrian Traffic:
   1. Location: At 3'-0" on center for the perimeter of the lightweight aluminum cover.
   2. Height: As directed by Engineer.
   3. Size: 14 inches wide by 10 inches high.
   4. Heading: DANGER
   5. Text: NO PEDESTRIAN TRAFFIC

END OF SCHEDULE A
PLASTIC SIGNAGE SYSTEM SCHEDULE

SCHEDULE B

METAL SAFETY SIGN SCHEDULE

E. NONPOTABLE WATER:
   1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: DANGER
   5. Wording: DO NOT DRINK THIS WATER

F. HIGH PRESSURE HOSE VALVES:
   1. Location: At designated hose valves.
   2. Height: As directed by Engineer
   3. Size: 14 inches wide by 10 inches high.
   4. Heading: DANGER
   5. Wording: HIGH PRESSURE

G. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:
   1. Location: On front and back of equipment that starts automatically by remote control.
   2. Height: As directed by Engineer.
   3. Size: 14 inches wide by 10 inches high.
   4. Heading: DANGER
   5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY
BY REMOTE CONTROL

H. HIGH VOLTAGE WARNING:
   1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
   2. Height: As directed by Engineer.
   3. Size: 14 inches wide by 10 inches high.
   4. Heading: DANGER
   5. Wording: HIGH VOLTAGE
KEEP OUT

I. NO SMOKING INFORMATIONAL SIGNS:
   1. Location: On exterior face of wall, adjacent to each entry point (exterior door) to all buildings.
   2. Height: 60 inches above floor to center of sign. Where metal safety signs are also located adjacent to entry points, place no smoking signs below these signs.
   3. Size: 6 inches square.
   4. Heading: None.
   5. Wording: None.
   6. Pictogram: International “No Smoking” symbol.

END OF SCHEDULE B
METAL SAFETY SIGN SCHEDULE

SECTION 10520

FIRE PROTECTION SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fire extinguishers.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 04220 - Concrete Unit Masonry.

1.02 REFERENCES

A. National Fire Protection Association (NFPA).

B. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Product Data.

B. Manufacturer's Installation Instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Regulatory requirements:
   1. Comply with UL requirements for classification type.

1.05 SEQUENCING AND SCHEDULING

A. Coordinate installation of blocking for anchoring of accessories in accordance with Section 04220.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fire extinguisher and cabinets: One of the following or equal:
   1. J.L. Industries, Bloomington, MN.
   2. Larsen's Manufacturing Company, Minneapolis, MN.
   3. Modern Metal Products by Muckle, Owatonna, MN.
   4. Watrous, Incorporated, Northbrook, IL.

2.02 FIRE EXTINGUISHERS

A. Type EFE10: UL 1A:10B:C with 10-pound capacity of colorless, odorless, electrically non-conductive liquefied gas, or clean agent as defined by NFPA , for extinguishing electrical fires without leaving residue.

2.03 WALL BRACKETS

A. Type: Standard as manufactured by fire extinguisher manufacturer.

2.04 ACCESSORIES

A. Extinguisher brackets: Formed steel, corrosion resistant finish, size and type to suit extinguisher.

B. Fasteners: Fasteners exposed in the final installation, with the door open and closed, shall be tamper-proof fasteners.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's recommendations.

B. Install products plumb, square, and level.

C. Place extinguishers: Locate 1 extinguisher as indicated.

3.02 SCHEDULE

A. Install fire extinguisher on wall brackets when fire extinguisher are indicated without cabinets.

END OF SECTION

SECTION 11312D

VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Vertical turbine pumps and drivers as scheduled.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Document 00700 - General Conditions.
      b. Section 01140 - Work Restrictions.
      c. Section 01600 - Product Requirements.
      d. Section 01610 – Project Design Criteria.
      e. Section 01756 - Commissioning and Process Start-Up.
      f. Section 01782 - Operation and Maintenance Data.
      g. Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      h. Section 09960 - High-Performance Coatings.
      i. Section 15050 - Common Work Results for Mechanical Equipment.
      j. Section 15958 - Mechanical Equipment Testing.
      k. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

C. American Water Works Association (AWWA):
   1. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe, 4 In. (100 mm) and Larger-Shop Applied.

D. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.

2. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. A 108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished.
4. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
5. A 278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (350°C).
6. A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
7. A 516- Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate-and Lower-Temperature Service.
8. A 582 - Standard Specification for Free-Machining Stainless Steel Bars.
9. A 743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
10. B 30 – Standard Specification for Copper Alloys in Ingot Form.
11. B 505 - Standard Specification for Copper Alloy Continuous Castings.
12. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
13. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
14. F 594 - Standard Specification for Stainless Steel Nuts.

E. Hydraulic Institute (HI):
1. 2.1-2.2 - Vertical Pumps for Nomenclature and Definitions.
2. 2.3 - Vertical Pumps for Design and Application.
3. 2.4 - Vertical Pumps for Installation Operation and Maintenance.
4. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, and Sound Measurement and Decontamination.
5. 14.6 – Rotodynamic Pumps For Hydraulic Performance Acceptance Tests.

F. International Standards Organization (ISO):
1. ISO 9001 Certified.

1.03 DEFINITIONS

A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 2.1-2.2, 2.3, 9.1-9.5, and 14.6 and as modified in the Specifications. The pump head and efficiency are evaluated at the outlet of the discharge head and include the net losses in the pump column and discharge.

B. Flow, head, efficiency, and motor horsepower specified in this Section are minimums unless stated otherwise.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric.

D. Tolerances: This Section and related sections contain tolerances that may be more stringent than Hydraulic Institute Standard tolerances. Where tolerances are not mentioned, Hydraulic Institute Standards 2.1-2.2, 2.3, 2.4, and 9.1-9.5 shall apply.

1.04 SYSTEM DESCRIPTION

A. Components: Pump, driver, motors, and drive arrangements as specified or as scheduled with shafts, columns, intermediate bearings, seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.

B. Design requirements:
   1. Pump performance characteristics:
      a. As specified in the Pump Schedule.
      b. Performance tolerances shall be the same as the test tolerances specified in Section 15958.
      c. Pump curve shall be continuously rising throughout the design conditions listed in the pump schedule.
   2. Motor characteristics: As specified in the Pump Schedule.

1.05 SUBMITTALS

A. Submit as specified in Section 15050.

B. Torsional analysis: Submit as specified in Section 15050 when scheduled.

C. Furnish motor submittals as specified in Section 16222.
   1. Pump certification per Section 01600.
   2. Weighted average lead calculations Section 01600.

D. Provide vendor operation and maintenance manual as specified in Section 01782.

1.06 QUALITY ASSURANCE

A. General: As specified in Section 15050.

B. Provide pumps specified in this Section from same manufacturer.

C. Manufacture's Certificate of Installation and Functionality Compliance as specified in Section 01756.

D. Pump manufacturer must be ISO 9001 certified.

E. Unit Responsibility:
   1. Manufacturers of this section shall be responsible for discharge head design and assembly, all fabrication, assembly, and testing of the completed pump shipping from the factory to the jobsite complete.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 15050.

1.08 PROJECT CONDITIONS

A. Environmental requirements: As specified in Section 01610.

1.09 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions as specified in Section 01140.

B. Coordinate work with Commissioning and Start-up as specified in Section 01756.

1.10 WARRANTY

A. Pumps specified in this Section, in addition to all other requirements specified in Section 15050, shall be warranted free from defects in workmanship, design, and materials for a period of two (2) years from the date of acceptance of the equipment or first beneficial use of the equipment. If any part of the equipment should prove to be defective during the warranty period, the pump manufacturer shall, at no expense to the Owner, replace the part.

1.11 MAINTENANCE

A. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

B. Spare parts: Deliver the following spare parts to Owner; pack and label for storage.
   1. Bowl assembly bearings: 1 set for each type of pump.
   2. Mechanical seal: 1 complete seal of each type.
   3. Motor bearing set: 1 for each size of motor.
   4. Pump impeller/bowl assembly: 1 of each type supplied.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. The following:
   1. Fairbanks Morse; model as scheduled.

2.02 MATERIALS

A. General:
   1. Pump Schedule materials: As specified in this Section.

B. Cast iron: ASTM A 48, Class 30 minimum.

C. Nickel cast iron: ASTM A 48, minimum Class 30, cast iron with 3 percent nickel.

D. Gray iron casting: ASTM A 278, Class 30.

E. Iron-chromium alloy: ASTM A 743, Grade CA40; ASTM A 276, Type 420 Stainless Steel may be substituted; Brinell Hardness Number of 350 to 380.

F. Lead-free bronze with only bearings that required lead for lubricity: ASTM B 584.

G. Leaded tin bronze: ASTM B 505, Alloy C92700.

H. Bronze or high lead tin bronze: ASTM B 584, Alloy 93800.

I. Leaded red brass: ASTM B 584, Alloy C83600, leaded red brass.

J. Type 416 stainless: ASTM A 582, Type 416 Stainless Steel.

K. Neoprene: Polychloroprene rubber.

L. Steel: ASTM A 283, Grade D or ASTM A 516 Gr. 70.

M. Steel pipe: ASTM A 53, Grade B.

N. Aluminum bronze meeting the requirements of Section 15050.

O. Lead-free aluminum bronze: ASTM B 30.

2.03 GENERAL PUMP CONSTRUCTION

A. Type: Industrial, heavy duty, vertical turbine, centrifugal type pumps meeting performance requirements and features as scheduled and as specified.

B. Discharge flange: ASME B16.1 or B16.5 drilled; rated for 1.2 times the pump shutoff head at 150 degrees Fahrenheit.

C. Discharge nozzles: Provide 1/2-inch NPT taps for pressure gauges; install nipple and gauge with block valve.

D. Bearings:
   1. Design driver/motor bearings to support the line shaft assembly and rated for ABMA L_{10} life of 40,000 hours at Design Rated Point flow and head in accordance with ABMA 9 or ABMA 11.
   2. Design motor to withstand continuous duty full load thrust and momentary upthrust that may occur during pump on/off or other operations.

E. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F 593 or ASTM F 594.

2.04 PUMP SUCTION ASSEMBLY

A. Pump suction assembly: Provide suction bell. Provide anti-vortex baffles and strainer when scheduled.

B. Design suction bells and provide strainers and anti-vortex baffles to minimize solids plugging and vortexing. Screens to have a flow area at least 4 times the suction pipe area.

C. Materials:
   1. Pump suction bell: As scheduled
   2. Anti-vortex baffles: Same material as scheduled for pump suction bell
   3. Pump suction bell bearing: As scheduled.
   4. Pump suction strainer: When strainer scheduled, provide Type 316 stainless steel.

2.05 PUMP IMPELLER BOWL ASSEMBLIES

A. Pump impeller assembly:
   1. Type: As scheduled.
   2. Maximum number of vanes: As scheduled.
   3. Number of stages: As scheduled.
   4. Required balance: As specified in Section 15050 to meet vibration criteria as specified in Section 15958.
   5. Method of securing impellers to shafts: Keyed and secured by a bronze nut locked in place or locked by other methods acceptable to the Engineer. Provide any special tools required for removal and installation of pump impellers.
   6. Provisions for adjustment of axial clearance: Make such adjustment through use of motor adjusting nut or adjustable coupling.
   7. Impeller thrust: When appropriate for the specified impeller type, provide hydraulically balanced impeller to minimize down thrust.

B. Intermediate and discharge impeller cases:
   1. Material: As scheduled.
   2. Attached with bolting.

C. Pump impeller bowl bearings: Provide bearing for each impeller; material as scheduled.

D. Diffusion vanes: Provide vanes cast into bowl.

E. Suction bowl bearings:
   1. Provide bronze sleeved bearings with self-contained lubrication system filled with graphite type non-soluble grease when grease lubrication scheduled; provide bearing with sand cap.
   2. When service is potable water, provide non-toxic grease approved by the Food and Drug Administration for use in potable water.

F. Design with smooth water passages to reduce clogging by stringy or fibrous materials on impellers or shafting.

G. Design capable of passing solids with a sphere size as scheduled or larger.

H. Design impellers capable of working on pumps that may be abnormally started against closed manual valve or normally against a closed pump control valve.

2.06 LINE SHAFTS

A. Provide line shaft type and lubrication type as scheduled and as specified in this Section.

B. Open line shaft, product lubricated:
   1. Shaft and couplings:
      a. Provide keyed shaft type mechanical couplings with key or set screw locking of shaft couplings.
      b. Shaft threaded connections are not allowed.
   2. Bearings and bearing retainers: Provide bearings and retainers spaced as scheduled, but not to exceed 10 feet; provide at least 1 bearing for each line

shaft length; provide grease fitting for top bearing extended to outside any guards when grease lubrication specified.

3. Materials:
   a. Shaft and couplings: As scheduled; where hard faced steel shaft is specified, hard face at sleeve bearings to 550 Brinell minimum.
   b. Bearings and bearing retainers: As scheduled; when not scheduled, Neoprene rubber bearings with bronze retainers.

C. Design strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

D. Resonant frequency: As specified in Sections 15050 and 15958.

E. Sleeves: Provide shafting with Type 304 stainless steel sleeve or hardened sleeves where shafts pass through bearings or stuffing boxes as scheduled; Brinell 550 or higher for hardened shaft; when the specified mechanical seals cannot be installed on a hardened shaft, hardened shafts are not required in the area of the mechanical seal.

F. Design pump line shafting in interchangeable lengths as scheduled, but not to exceed 10 feet; shaft lengths to match scheduled pump column lengths.

G. Coupling strength: Design driver to pump line shaft coupling of sufficient length and strength to maintain line shaft alignment.

H. Adjustment:
   1. Design a means to adjust shaft position to adjust impeller position.
   2. For motor driven units with solid shaft motors, design driver to pump line shaft coupling to allow adjustment of the impeller position.
   3. For motor driven units with hollow shafts, an adjusting nut may be provided at the top of the motor shaft.

I. Spacer coupling: When mechanical seals are scheduled, provide an adjustable spacer coupling to allow removal of the seal without driver removal.

2.07 PUMP COLUMN PIPE

A. Pump column pipe: Thickness and material as scheduled.

B. Head connection: Design with flanged and bolted connection to discharge head and flanged and bolted connection to impeller assembly to permit removal of impeller bowl assembly without disturbing the column or discharge connections.

C. Design Working Pressure: Design to withstand a design working pressure not less than 1.20 times the maximum shutoff total dynamic head with the maximum diameter impeller at the maximum operating speed plus the maximum suction static head.

D. Pressure test: Design to withstand a 5 minute hydrostatic test pressure not less than 1.5 times the design working pressure; perform test at source.

E. Lengths and connections: Design with maximum 10 foot length, or less if scheduled, interchangeable column sections with flanged or threaded with registered fit screwed connections as scheduled.

F. Diameter: Design column inside diameter for no more than 4 feet of fluid friction loss per 100 feet of column length.

2.08 PUMP DISCHARGE HEAD ASSEMBLY

A. Design the discharge head for above or base discharge as scheduled.

B. Design the discharge vertical to horizontal flow transition as a smooth pipe elbow or from a minimum of 3 pipe pieces mitered to form the elbow.

C. Design discharge head to mate with the driver as scheduled.

D. Head and base plate construction: Sufficient strength, weight, and thickness to provide accurate alignment, prevent excessive deflection and support the drive motor.

E. Stuffing box and seal:
   1. Design the discharge head with a stuffing box to accommodate packing or mechanical seals as scheduled.
   2. Packing: When packing scheduled, provide stuffing box arranged for packing (sized for bronze lantern ring and 6 packing rings minimum); provide hollow shaft motor with top adjusting nut.
   3. Mechanical seal: When scheduled, provide stuffing box suitable for the specified seal and provide solid shaft motor with spacer coupling.
   4. Additional seal or packing requirements: As specified in Section 15050.
   5. Drain: Provide drain, minimum 3/4 inch size, for pump stuffing box leakage, together with drain line to the pump can or wet well or to nearest equipment drain as indicated on the Drawings**.**

F. Discharge vent: Provide 3/4 inch NPT threaded high point vent on discharge; install pipe nipple with threaded gate valves in vent.

G. Materials: As scheduled; when not scheduled, provide:
   1. Pump discharge head/driver stand: Steel, ASTM A 283, Grade B and/or ASTM A 53, Grade B; or Cast iron, ASTM A 48, Class 30 minimum.
   2. Pump discharge head sleeve bearing: Bronze.
   3. Stuffing box and seal: Container and gland, Cast iron, ASTM A 48, Class 30 minimum; Neoprene top shaft seal.

2.09 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 15050.

2.10 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.

a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
c. Make all structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors: Provide inverter duty motors suitable for operation with variable frequency drives when scheduled.
1. All motors shall include insulated bearings and shaft grounding brush assemblies.

C. Other drivers: As scheduled and as specified in sections listed in the Schedule.

D. Non-reverse ratchets: When scheduled, provide driver with nonreverse ratchets or pin mechanism to prevent reverse rotation of the pump and driver in the event of discharge valve failure.

2.11 SUPPORTS

A. Strength: Design pump discharge head and driver (motor or engine) supports to withstand a minimum of 1.5 times the maximum imposed operating loads or the imposed seismic loads, whichever is greater.

B. Resonant frequency: Design supports in conjunction with the pump, shafting, drivers, bearings, and other components to avoid natural resonant frequencies, either torsional, radial, or axial as specified in Section 15958.

C. Coordinate pump and drive system supports with the foundation designs as indicated on the Drawings.

D. Anchor bolts: As specified in Section 05190.

2.12 FINISHES

A. Prepare surfaces and apply protective coatings as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be as indicated on the Drawings, in accordance with written instructions of the manufacturer, and as specified in Section 15050.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:

			Manufacturer Rep Onsite					
	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Source Testing (Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Witnessed	4	2	1	1	1	1	24 hour on-call	

C. Source Testing:
1. Pump:
   a. Test witnessing: As scheduled and as specified in Section 01756.
   b. Performance test: Test level as scheduled; test as specified in Section 15958.
   c. Vibration test: Test level as scheduled; test as specified in Section 15958.
   d. Noise test: Test level as scheduled; test as specified in Section 15958.
2. Pump casing: Hydrostatic pressure tests if specified in this Section.
3. Motor: Test as specified in Section 16222.

D. Functional Testing:
1. Pump assembly:
   a. Performance test: Test level as scheduled; test as specified in Section 15958.
   b. Vibration test: Test level as scheduled; test as specified in Section 15958.
   c. Noise test: Test level as scheduled; test as specified in Section 15958.
2. Motor: Test as specified in Section 16222.

3.03 PUMP SCHEDULE

Tag Numbers	20-PMP-101 20-PMP-102
General Characteristics:	
Application	Reclaimed Wastewater
Service	Injection Well Supply Pumps
Quantity	2
First Named Manufacturer's Model Number	10M-SS
Maximum Noise, dBA at 3 feet	85
Torsional Analysis	Required
Minimum Pumped Fluid Degrees Fahrenheit	50
Normal Pumped Fluid Degrees Fahrenheit	70
Maximum Pumped Fluid Degrees Fahrenheit	85
Pump Characteristics:	
Number of Stages	Per Manufacturer

Tag Numbers	20-PMP-101 20-PMP-102
Impeller Type	Enclosed
Impeller, Maximum Number of Vanes	Per Manufacturer
Pass Minimum Sphere Size, Inch	0.63
Pump Impeller Bowl Bearing Lubrication	Product Water Lubricated
Suction Bowl Bearing Lubrication	Grease
Suction Strainer	Required
Anti-Vortex Baffle	Required
Line Shaft Type	Open
Minimum Line Shaft Bearing Spacing, Feet	10
Line Shaft Lubrication	Product Water Lubricated
Discharge Shaft Seal Type	Single Mechanical
Column Connection Type	Flanged
Maximum Column Section Lengths, Feet	10
Discharge Arrangement	Above Base
Coupling Type	Spacer
Speed Control	Variable Frequency Drive
Maximum Pump rpm	1,200
Minimum Pump rpm	600
Rated Design Point (at Maximum Revolutions per Minute):	
Flow, gpm	350
Head, Feet	103
Minimum Efficiency, Percent	80
Required Condition 2 (at Maximum Revolutions per Minute):	
Flow, gpm	375
Head Range, Feet	100
Minimum Efficiency, Percent	80
Required Condition 3 (at Maximum Revolutions per Minute):	
Flow, gpm	275
Head Range, Feet	120
Minimum Efficiency, Percent	80
Required Condition 4 (at Reduced Speed):	
Flow, gpm	125

Tag Numbers	20-PMP-101 20-PMP-102
Head Range, Feet	44
Minimum Efficiency, Percent	75
Other Conditions:	
Shut Off Head, Feet	145
Maximum NPSHr at every Specified Flow, Feet	6
Minimum NPSHa at every Specified Flow, Feet	30
Minimum Suction Static Head, Feet	2
Maximum Suction Static Head, Feet	10
Pump Materials:	
Suction Bell	Cast Iron
Suction Bell Bearing	Aluminum Bronze
Impeller Cases	Cast Iron
Impeller	Aluminum Bronze
Impeller Bearing	Aluminum Bronze
Impeller Shaft Key	Type 416 Stainless Steel
Line Shaft and Coupling	Type 416 Stainless Steel
Line Shaft Bearings	Fluted Buna-N
Shaft Sleeve	None
Column Material and Thickness, Inch	Steel Pipe, 0.375
Discharge Head/Driver Stand	Fabricated Steel
Discharge Head Bearing	Aluminum Bronze
Discharge Stuffing Box	Cast Iron
Driver Characteristics:	
Driver Type	Motor with Variable Frequency Drive
Drive Arrangement	Vertical, Coupled
Non-Reverse Ratchets	Required
Minimum Driver Horsepower	15
Maximum Driver rpm	1,200
Motor Characteristics (when motor is driver type):	
Inverter Duty Rated	Yes
Motor Voltage/Phases/Hertz	460/3/60
Enclosure Type	TEFC

Tag Numbers	20-PMP-101 20-PMP-102
Source Testing:	
Test Witnessing	Factory PE Witnessed
Performance Test Level	1
Vibration Test Level	-
Noise Test Level	-
Functional Testing:	
Performance Test Level	1
Vibration Test Level	1
Noise Test Level	1

END OF SECTION

SECTION 11312J

SUBMERSIBLE PROCESS LIQUID SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Packaged submersible sump pumps, with a control panel and instrumentation.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01140 - Work Restrictions.
      b. Section 01600 - Product Requirements.
      c. Section 01610 - Project Design Criteria.
      d. Section 01756 - Commissioning and Process Start-Up.
      e. Section 01782 - Operation and Maintenance Data.
      f. Section 09960 - High-Performance Coatings.
      g. Section 15050 - Common Work Results for Mechanical Equipment.
      h. Section 15958 - Mechanical Equipment Testing.
      i. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      j. Section 16412 - Low Voltage Molded Case Circuit Breakers.
      k. Section 17201 - Level Measurement: Switches.
      l. Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
   3. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.

B. Hydraulic Institute (HI):
   1. 1.1-1.2 - Centrifugal Pumps for Nomenclature and Definitions.
   2. 1.3 - Rotodynamic (Centrifugal) Pumps for Design and Application.
   3. 9.1-9.5 - Pumps - General Guidelines for Types, Application, Definitions, Sound Measurement, and Documentation.
   4. 11.6 - Submersible Pump Tests.

C. National Electrical Manufacturers Association (NEMA):

1. 250 - Enclosures for Electrical Equipment (1000 V Maximum)

1.03 DEFINITIONS

A. NEMA:
   1. As specified in 16050.

B. Pump head (Total Dynamic Head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 1.1-1.2, 1.3, 9.1-9.5 and 11.6 and as modified in this Section.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 SYSTEM DESCRIPTION

A. Components: Overhung impeller, close coupled, single stage, volute style, end suction submersible sewage pump. Other items include: Control panel, level control instrumentation, discharge piping, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.

B. Design requirements:
   1. Pump performance characteristics: As specified in the Pump Schedule, Pump Performance Characteristics:
      a. As specified in the Pump Schedule.
      b. Performance tolerances shall be the same as the test tolerances specified in Section 15958.
   2. Motor characteristics: As specified in the Pump Schedule.
   3. Suitable for pumping raw sewage.

1.05 SUBMITTALS

A. Submit as specified in Section 15050.

B. Calculations per Section 15050 are not required for pumps specified in this Section.

C. Furnish motor submittals as specified in Section 16222.

D. Manufacturer’s Representatives qualifications as specified in Section 01756.

E. Provide vendor operation and maintenance manual as specified in Section 01782.

1.06 QUALITY ASSURANCE

A. As specified in Section 15050.

B. Provide pumps specified in this Section from same manufacturer.

C. Manufacture’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 15050.

1.08 PROJECT CONDITIONS

A. Environmental requirements: As specified in Section 01610.

1.09 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions specified in Section 01140.

B. Coordinate work with Commissioning and Start-up as specified in Section 01756.

1.10 WARRANTY

A. Provide a Manufacturer's warranty meeting the requirement of the General Conditions.

1.11 MAINTENANCE

A. Special tools: For each type or size of pump specified, provide 1 set of all special tools required for complete assembly or disassembly of the pump system components.

B. Spare parts: Deliver the following as specified in Section 01600:
   1. Pump impeller, trimmed to match installed impeller.
   2. Mechanical seal set.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Pumps: One of the following or equal:
   1. Hydromatic, SK50.
   2. Barnes. (Crane Pumps & Systems), SE series.
   3. ITT Goulds Pumps, WS_ series.

2.02 MATERIALS

A. Cast Iron: ASTM A 48, Class 30 minimum

B. Stainless Steel: ASTM A 276 or equal.

C. Buna N: ASTM D 2000.

2.03 PUMP CASING

A. Material: Cast iron.

B. Design Working Pressure: 1.5 times the shut off pressure.

C. Provide support legs on sump bottom and clearance for suction entrance.

D. The discharge connection shall be a 2 or 3-inch NPT vertical connection.

2.04 IMPELLERS

A. Material: Cast iron.

B. 2-vane; maximum enclosed; nonclogging; with pump-out vanes on backside; dynamically balanced; close coupled to motors.

C. Method of securing to shafts: Treaded lock nut or similar connection.

2.05 PUMP SHAFTS

A. Material: 400 series stainless steel.

2.06 BEARINGS

A. Upper bearing: Single row; oil lubricated.

B. Lower bearing: Single row; oil lubricated.

2.07 SHAFT SEAL

A. Single mechanical seal.

B. Materials:
   1. Silicon carbide versus silicon carbide seal faces
   2. Carbon versus ceramic seal faces.

C. Elastomer and hardware: Buna-N and 300 series stainless steel.

2.08 DRIVERS

A. Motors:
   1. NEMA B design.
   2. Oil filled submersible motor.
   3. Insulation:
      a. 1.5 horsepower and above: Class B.
      b. Under 1.5 horsepower: Class B.
   4. Power: 120 VAC, 1 phase, 60 hertz.
   5. 1.15 service factor.
   6. Pumps shall be able to operate continuously without exceeding pumps service capacity when immersed in water up to 104 degrees Fahrenheit
   7. Cable: Minimum length sump depth to the VCP, plus 15 feet, armored, waterproof cable securely attached to motors with watertight fittings.

2.09 ACCESSORIES

A. Chains or cables: Stainless steel; attached to balance point of pump; suitable for lifting pump from sump; long enough to extend from sump cover or grating.
   1. Hooks: Suitable to provide storage of chain or cable at top of sump.

2.10 FINISHES

A. Pump manufacturer to factory prime and coat pump/motor and discharge elbow as specified in Section 09960.

B. Contractor to provide touch-up field coatings as specified in Section 09960.

2.11 CONTROLS

A. General:
1. Provide a vendor control panel at each installation for control of the pumps, except as indicated on the pump schedule.

B. Vendor control panel:
1. Construction and components as specified in Section 17710.
2. Enclosure:
    a. As indicated in the pump schedule.
3. Electrical components:
    a. Main circuit breaker:
        1) As specified in Section 16412.
        2) Flange-mounted operator:
            a) Pad-lockable in the off position.
        3) Disconnects all power to the panel.
        4) Interlock with the panel door.
            a) Defeat mechanism.
    b. Motor starter for each pump:
        1) Motor circuit protector circuit breaker.
        2) Full voltage non-reversing magnetic starter.
        3) Thermal or electronic overloads.
    c. Control power transformer:
        1) Primary voltage: 120 VAC, 1 phase, 60 hertz.
        2) Secondary voltages:
            a) Control and status points to the facility SCADA system: 120 volt.
            b) Additional voltages as required by the application.
        3) Sized for all panel components plus 10 percent spare capacity.
        4) Primary and secondary fuses.
4. Control components:
    a. Terminal strips:
        1) Provide terminal strips for landing all external wiring.
    b. Relays, timers, and other components as required providing the specified functionality and remote monitoring connections.
5. Duplex operation
    a. Front Panel Controls:
        1) HAND/OFF/AUTO switch.
        2) START pushbutton for each pump.
        3) STOP pushbutton for each pump.
        4) LEAD-STANDBY selector switch which will permit operator selection of either Pump Number 1 or Pump Number 2 as the lead pump during automatic operation
        5) Momentary LOW LEVEL OVERRIDE pushbutton.
        6) Running pilot light for each pump.
        7) Stopped pilot light for each pump.

8) Power pilot light.
9) Pump fault pilot light for each pump.
10) High-High level alarm.
11) Alarm beacon.
    a) Alarm silence pushbutton.

b. Remote monitoring and control:
    1) Provide dry relay contact outputs for the following:
        a) Pump Fault alarm: one for each pump.
        b) Pump Run status: each pump.
        c) High-High Level Alarm.

c. Operation:
    1) Hand:
        a) The pump shall run when the START pushbutton is pressed.
        b) The pump shall stop when the STOP pushbutton is pressed
        c) The LOW-level switch shall stop the pump.
        d) The LOW-level switch shall be over ridden by the momentary LOW LEVEL OVERRIDE pushbutton.
    2) Off: Pump shall stop operation.
        a) Placing the hand switch in the OFF position shall re-set all alarm conditions.
    3) Auto: The pump shall operate automatically in response to level switch signals.
        a) The lead pump shall start when the rising water level in the sump causes level switch HIGH-level switch to activate.
        b) The lead pump shall stop when the falling water level in the sump causes level switch LOW-level switch to activate.
        c) If the lead pump fault alarm is activated the standby pump shall replace the lead pump.
        d) A high- high level shall cause the HIGH–HIGH level switch to activate and activate the HIGH–HIGH level alarm.

2.12 LEVEL SENSOR

A. Type: Ball float as specified in Section 17201.

B. Cable Length: The length of the cable shall be equal to sump depth to the VCP plus 5 feet.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be as indicated on the Drawings, in accordance with written instructions of the manufacturer, and as specified in Section 15050.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section. If there are discrepancies, the most stringent requirements shall prevail.

B. Manufacturer services:

			Manufacturer Rep Onsite					
	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Source Testing (Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Not Witnessed	4	2	1	1	1	1	24 hour on-call	

C. Source Testing:
1. Pump:
   a. Test witnessing: Not Required
   b. Performance test: Not Required
   c. Vibration test: Not required.
   d. Noise test: Not required.
2. Pump casing: Hydrostatic pressure tests if specified in this Section.
3. Motor: Test as specified in Section 16222.

D. Functional Testing:
1. Pump assembly:
   a. Performance test: Test level as scheduled; test as specified in Section 15958.
   b. Vibration test: Not required.
   c. Noise test: Not required.
2. Motor: Test as specified in Section 16222

3.03 PUMP SCHEDULE

A. Pump characteristics:

Tag Numbers	**40-SMP-101, 40-SMP-102**
Location	Injection Well No. 1 Analyzer Waste Sump
Service	Analyzer waste water
Pump Type	Duplex
Capacity, gpm	30 gpm
Total Dynamic Head (TDH), Feet	20 feet
Motor Horsepower	0.5
Min. Shutoff Head, feet	9 feet
Motor Speed, revolutions per minute	1,750 rpm
VCP Required	Yes
VCP Enclosure	Per Spec 16050

END OF SECTION

SECTION 11313I

DEEP WELL VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pump systems including vertical turbine pumps with radial, mixed flow, or axial (propeller) type impellers and drivers as scheduled.

B. Related section:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01756 - Testing, Training, and Facility Start-Up.
      b. Section 15050 - Common Work Results for Mechanical Equipment.
      c. Section 15958 - Mechanical Equipment Testing.
      d. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C654 - Disinfection of Wells.

B. ASTM International (ASTM):
   1. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   2. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
   3. A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   4. A 536 - Standard Specification for Ductile Iron Castings.
   5. A 582 - Standard Specification for Free Machining Stainless Steel Bars.
   6. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   7. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   8. F 594 - Standard Specification for Stainless Steel Nuts.

C. The Hydraulic Institute (HI):
   1. 2.1-2.2 - Rotodynamic (Vertical) Pumps for Nomenclature and Definitions.
   2. 2.3 - Rotodynamic (Vertical) Pumps for Design and Applications.
   3. 2.4 - Rotodynamic (Vertical) Pumps for Installation Operations and Maintenance.

4. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination.
5. 14.6 - Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

D. National Electrical Manufacturers Association (NEMA).

E. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.

F. International Standards Organization (ISO):
1. 9001 - Quality Management Systems - Requirements.

1.03 DEFINITIONS

A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 2.1-2.2, 2.3, 2.4, 9.1-9.5, and 14.6 and as modified in the Specifications. The pump head and efficiency are evaluated at the outlet of the discharge head and include the net losses in the pump column and discharge.

B. Flow, head, efficiency, and motor horsepower specified in this Section are minimums unless stated otherwise.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric.

D. Tolerances: This Section and related sections contain tolerances that may be more stringent than Hydraulic Institute Standard tolerances. Where tolerances are not mentioned, Hydraulic Institute Standards 2.1-2.2, 2.3, 2.4, and 9.1-9.5 shall apply.

1.04 SYSTEM DESCRIPTION

A. Components: Pump, driver, motors, and drive arrangements as specified or as scheduled with shafts, columns, intermediate bearings, seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.

B. Design requirements:
1. Pump performance characteristics:
a. As specified in the Pump Schedule.
b. Performance tolerances shall be the same as the test tolerances specified in Section 15958.
c. Pump curve shall be continuously rising throughout the design conditions listed in the pump schedule.
2. Motor characteristics: As specified in the Pump Schedule.

1.05 SUBMITTALS

A. Submit as specified in Section 15050.

B. Torsional analysis: Submit as specified in Section 15050 when scheduled.

C. Furnish motor submittals as specified in Section 16222.

D. Furnish submersible pressure transmitter as specified in Section 17407.

1.06 QUALITY ASSURANCE

A. General: As specified in Section 15050.

B. Provide pumps specified in this Section from same manufacturer.
   1. Require pump manufacturer to furnish and coordinate pump, driver, drive, and pump components as scheduled and to provide written installation and checkout requirements.

C. Pump manufacturer: Preferred to be ISO 9001 certified.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 15050.

1.08 PROJECT CONDITIONS

A. Environmental requirements: As specified in Section 01610.

1.09 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions as specified in Section 01140.

1.10 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions as specified in Section 01140.

1.11 WARRANTY

A. As specified in Section 15050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. National Pump Company; as scheduled.
   2. American-Turbine; similar to scheduled model.
   3. Weir/Floway; similar to scheduled model.
   4. Flowserve; similar to scheduled model.

2.02 MATERIALS

A. General:
   1. Materials in the Pump Schedule shall be the type and grade as specified in this Section.
   2. Lead Limits: As specified in Section 15050.

B. Cast iron: In accordance with ASTM A 48, Class 30 minimum.

C. Ductile Iron: In accordance with ASTM A 536, 65-45-12.

D. Tin Bronze: In accordance with ASTM B 584, Alloy C90300.

E. Silicon Bronze: In accordance with ASTM B 584, Alloy C87600.

F. Red Bronze: In accordance with ASTM B 584, Alloy C83600.

G. Type 416 Stainless Steel: In accordance with ASTM A 582.

H. Type 304 Stainless Steel: In accordance with ASTM A 276.

I. Steel: In accordance with ASTM A 283, Grade D or ASTM A 516 Gr. 70.

J. Steel pipe: In accordance with ASTM A 53, Grade B.

2.03 GENERAL PUMP CONSTRUCTION

A. Type: Industrial, heavy duty, vertical turbine, centrifugal type pumps meeting performance requirements and features as scheduled and as specified.

B. Discharge flange: ASME B16.1 or B16.5 drilled; rated for 1.2 times the pump shutoff head at 150 degrees Fahrenheit.

C. Discharge nozzles: Provide 1/2-inch NPT taps for pressure gauges; install nipple and gauge with block valve.

D. Bearings:
   1. Column shaft bearings to be provided for oil lubrication service with helical grooves cut on the inside of the bearing.
   2. Design driver/motor bearings to support the line shaft assembly and rated for ABMA L_{10} life of 40,000 hours at Design Rated Point flow and head in accordance with ABMA 9 or ABMA 11.
   3. Design motor to withstand continuous duty full load thrust and momentary upthrust that may occur during pump on/off or other operations.

E. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F 593 or ASTM F 594.

2.04 PUMP SUCTION ASSEMBLY

A. Suction case shall be taper threaded to accept an inlet strainer.

B. A sand collar shall be pressed on or set screwed to the bowl shaft, immediately above the housing.

C. Materials:
   1. Suction case: A48 Class 30 cast iron.
   2. Suction bearing: Bronze with Buna-N A40 rubber or Buna-N A40 rubber (marine).
   3. Sand collar: Bronze.
   4. Suction plug: Cast iron.
   5. Suction strainer: 316SS.

2.05 IMPELLER BOWL ASSEMBLIES

A. Pump impeller assembly:
   1. Type: As scheduled in the Pump Schedule.
   2. Number of stages: As scheduled in the Pump Schedule.
   3. Material: Silicon Bronze.
   4. Required balance: As specified in Section 15050 to meet vibration criteria as specified in Section 15958.
   5. Method of securing impellers to shafts: Tapered collets or locked by other methods acceptable to the ENGINEER.
   6. Impellers shall be of the enclosed type, cast in 1 piece, and statically balanced.

B. Provisions for adjustment of axial clearance: Make such adjustment through use of motor adjusting nut or adjustable coupling.

C. Impeller Shafts:
   1. Material: 416SS.
   2. Turned, ground and polished.

D. Intermediate and discharge impeller cases:
   1. Material: As scheduled.
   2. Attached with bolting.

E. Pump impeller bowl bearings:
   1. Provide bearing for each impeller.
   2. Materials: Marine.

F. Discharge and Suction bowl bearing:
   1. Provide bronze bearings with self-contained lubrication system filled with graphite type non-soluble grease when grease lubrication scheduled; provide bearing with sand cap.
   2. When service is potable water, provide non-toxic grease approved by the Food and Drug Administration for use in potable water.

G. Design with smooth water passages to reduce clogging by stringy or fibrous materials on impellers or shafting.

2.06 SUCTION ADAPTOR

A. Material: Cast Iron.

B. Provide a 316 stainless steel strainer.

C. Designed to prevent entrance of abrasive material into the top end of the motor.

2.07 LINE SHAFTS AND ENCLOSING TUBES

A. Provide line shaft type and lubrication type as scheduled and as specified in this Section.

B. Enclosed line shaft, oil lube:
   1. Shaft and couplings: Provide threaded shaft couplings.

2. Shaft bearings and spiders: Provide bearings and retainers as scheduled, but not to exceed 5 feet for bearings and 40 feet for spiders.
3. Line shaft: 1-1/4” inch.
4. Enclosing tube: 2-inch - Schedule 80; lengths to be no greater than 5 feet.
5. Materials: As scheduled; when not scheduled provide:
    a. Shaft: C-1045 carbon steel.
    b. Shaft couplings: carbon steel.
    c. Shaft bearings: Bronze.
    d. Spiders: Neoprene rubber spider on enclosing tube.
    e. Enclosing tube: Schedule 80.

C. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

D. Resonant frequency: As specified in Sections 15050 and 15958.

E. Design pump line shafting in interchangeable lengths as scheduled, but not to exceed 20 feet; shaft lengths to match scheduled pump column lengths.

F. Coupling strength: Design driver to pump line shaft coupling of sufficient length and strength to maintain line shaft alignment.

G. Adjustment:
1. Design a means to adjust shaft position to adjust impeller position.
2. For motor driven units with hollow shafts, an adjusting nut may be provided at the top of the motor shaft.

2.08 COLUMN PIPE

A. Material: 6-inch (Schedule 40) Grade A 53 B Taper Threaded, T&C.

B. Design Working Pressure: Design to withstand a design working pressure not less than 1.20 times the maximum shutoff total dynamic head with the maximum diameter impeller at the maximum operating speed plus the maximum suction static head.

C. Pressure test: Design to withstand a 5-minute hydrostatic test pressure not less than 1.5 times the design working pressure; perform test at source.

D. Lengths and connections:
Design with maximum 20-foot length, or less if scheduled, interchangeable column sections with threaded with registered fit screwed connections as scheduled.

E. Diameter: Design column inside diameter for no more than 4 feet of fluid friction loss per 100 feet of column length.

2.09 PUMP DISCHARGE HEAD ASSEMBLY

A. Design the discharge head for above or base discharge as scheduled.

B. Design the discharge vertical to horizontal flow transition as a smooth pipe elbow or from a minimum of 3 pipe pieces mitered to form the elbow.

C. Design discharge head to mate with the driver as scheduled.

D. Head and base plate construction: Sufficient strength, weight, and thickness to provide accurate alignment, prevent excessive deflection and support the drive motor.

E. Packed assembly at tube tension nut.

F. Discharge vent: Provide 3/4-inch NPT threaded high point vent on discharge; install pipe nipple with threaded gate valves in vent.

G. Materials: As scheduled; when not scheduled, provide
   1. Pump discharge head/driver stand: Steel, ASTM A 283, Grade B and/or ASTM A 53, Grade B; or Cast iron, ASTM A 48, Class 30 minimum.
   2. Pump discharge head sleeve bearing: ASTM B 584, Alloy C93800, high lead tin bronze.

2.10 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 15050.

2.11 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.
      a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
         1) When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
         2) Contractor shall be responsible for all costs associated to make all structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors: Provide motors as specified in Section 16222 and as specified in this Section:
   1. NSF Standard 61 certified.
   2. Revolutions per minute: As scheduled in the Pump Schedule.
   3. Enclosure: As scheduled in the Pump Schedule.
   4. Motor accessories: As specified in Section 16222 and in this Section.

C. Other drivers: As scheduled and as specified in sections listed in the Schedule.

D. Non-reverse ratchets: When scheduled, provide driver with non-reverse ratchets or pin mechanism to prevent reverse rotation of the pump and driver in the event of discharge valve failure.

2.12 SUPPORTS

A. Strength: Design pump discharge head and driver (motor or engine) supports to withstand a minimum of 1.5 times the maximum imposed operating loads or the imposed seismic loads, whichever is greater.

B. Resonant frequency: Design supports in conjunction with the pump, shafting, drivers, bearings, and other components to avoid natural resonant frequencies, either torsional, radial, or axial as specified in Section 15958.

C. Coordinate pump and drive system supports with the foundation designs as indicated on the Drawings.

2.13 ACCESSORIES

A. Pressure transmitter enclosing tube:
   1. The pressure transmitter enclosing tube shall be 1-1/4 -inch Schedule 80 PVC.
      a. The pipe shall be furnished in 1-1/4-inch I.D., 20 feet - 0 inches foot joints with threaded ends suitable for couplings.
      b. Couplings: Flush Joint (threaded).
      c. Tube shall be strapped to the pump column pipe every 30 feet with stainless steel bands.
      d. Access tube shall extend to the top of the pump bowls (approximate depth of 300 feet). The access tube shall extend through the sole plate and be fitted with a threaded cap.

2.14 FINISHES

A. Prepare surfaces and apply protective coatings as specified in Section 09960.

B. Apply coatings to discharge head and motor as specified in Section 09960.

2.15 SOURCE QUALITY CONTROL

A. Witnessing: Source or factory testing shall be witnessed by the ENGINEER or OWNER when scheduled; provide advanced notice of source testing as specified in Section 15958.

B. Equipment performance test: Test level as scheduled; test as specified in Section 15958.

C. Vibration test: Test level as scheduled; test as specified in Section 15958.

D. Motor factory tests: Test as specified in Section 16222.

E. Hydrostatic pressure tests: As specified for components in this Section.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions and as specified in Section 15050.

3.02 STERILIZATION

A. Disinfection procedures shall be in accordance with AWWA C654.

B. The water discharged by the pump following disinfection shall be dechlorinated to a level of 2.0 or less milligrams per liter chlorine before it is allowed to leave the site.

3.03 FIELD QUALITY CONTROL

A. Witnessing: All field testing shall be witnessed by the ENGINEER; provide advanced notice of field testing as specified in Sections 01756 and 15958.

B. Inspection and checkout: As specified in Sections 15050 and 15958.

C. Equipment performance test: Test level as scheduled; test as specified in Section 15958.

D. Vibration test: Test level as scheduled; test as specified in Section 15958.

E. Operational testing: As specified in Section 01756.

3.04 MANUFACTURER'S FIELD SERVICE

A. Require manufacturer to inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up as specified in this Section and in Sections 15050 and 15958.

B. Training: As specified in Section 01756.

3.05 REVERSE FLOW TEST

A. Coordinate reverse flow test of the bowl assembly with pump manufacturing facility:
   1. Develop recharge pump curve using bowl assembly that will be shipped to owner. Pump curve shall show flow in GPM along the X-axis and headloss in feet along the Y-axis.
   2. Pressure loss through bowl assembly to be measured by pressure instruments located directly above and directly below the bowl assembly.
   3. Recharge data shall include at least 8 data points between 50 gpm and 400 gpm, spaced at approximately 50 gpm between each point.
   4. If the recharge pressure loss across the bowl assembly is less than 500 ft at 400 gpm, then take two more data points at increased flow rates of 450 gpm and 500 gpm.

B. Submittal: Submit recharge curve with pump submittal per Section 15050.

C. Additional coordination: When recharge test has been plotted, send recharge curve to engineer for review. If the recharge curve shows that the bowl assembly is too large or too small for the desired recharge operating range, another bowl assembly may be selected and tested.

D. Cost estimate: Contractor shall include in their bid the testing of two (2) separate bowl assemblies.

3.06 PUMPS SCHEDULE

Tag Numbers	Injection Well No. 1	Injection Well No. 2
General Characteristics:		
Service	Reclaimed water	Reclaimed water
Quantity	1	1
Inner / Outer Casing Diameter at land surface, inches	N/A	N/A
First Named Manufacturer's Model Number	National Pump Company, M8MC	National Pump Company, M8MC
Maximum Noise, dBA at 3 feet	85	85
Torsional Analysis	Required	Required
Minimum Pumped Fluid Degrees Fahrenheit	50	50
Normal Pumped Fluid Degrees Fahrenheit	70	70
Maximum Pumped Fluid Degrees Fahrenheit	85	85
Estimated static water level to surface, feet	470	470
Estimated pumping water level to surface, feet	570	570
Estimated discharge static head above surface (incl. friction losses), feet of water	30	30
Estimated Total Dynamic Head (TDH), feet of water	600	600
Column pipe, air line and pressure transducer setting, feet below surface	580	580
Pump Characteristics:		
Impeller type	Enclosed	Enclosed
Pump Impeller Bowl Bearing Lubrication	Product	Product
Suction Strainer	316SS	316SS
Line Shaft Type	Enclosed	Enclosed
Minimum Line Shaft Bearing Spacing, Feet	5	5
Line Shaft Lubrication	Food Grade Oil	Food Grade Oil
Throttle Bearing	Bronze	Bronze
Column Connection Type	Threaded	Threaded
Maximum Column Section Lengths, Feet	20	20
Coupling Type	Threaded	Threaded
Column pipe internal diameter, inches	6	6
Speed Control	Constant	Constant
Maximum Pump rpm	1,770	1,770
Rated Design Point (at Maximum Revolutions per Minute):		
Flow, gpm	300	300
Total Dynamic Head, Feet	600	600
Minimum Efficiency, Percent	80	80

Tag Numbers	Injection Well No. 1	Injection Well No. 2
Required Condition 2 (at Maximum Revolutions per Minute):		
Flow, gpm	350	350
Head Range, Feet	504	504
Minimum Efficiency, Percent	75	75
Required Condition 3 (at Maximum Revolutions per Minute):		
Flow, gpm	250	250
Head Range, Feet	650	650
Minimum Efficiency, Percent	75	75
Other Conditions:		
Minimum Shut Off Head, Feet	700	700
Pump Materials:		
Suction Bearing	Marine	Marine
Impeller Cases	Cast iron	Cast iron
Impeller (enclosed)	CDAH76 bronze	CDAH76 bronze
Impeller Bearing	Marine or bronze	Marine or bronze
Impeller Shaft Collet	316SS	316SS
Bowl Shaft	416SS	416SS
Line Shaft	C-1045 Carbon Steel	C-1045 Carbon Steel
Line Shaft Coupling	Carbon Steel	Carbon Steel
Line Shaft Bearings	Bronze	Bronze
Shaft Enclosing Tube	Schedule 80 Steel Pipe	Schedule 80 Steel Pipe
Column Material and Thickness, Inch or Schedule	Steel Pipe, Schedule 20	Steel Pipe, Schedule 20
Discharge Head/Driver Stand	A36 & A53 gr. B or APE X42 steel or Cast Iron	A36 & A53 gr. B or APE X42 steel or Cast Iron
Tube Tension Assembly	Bronze	Bronze
Packing Seal	per Manufacture	per Manufacture
Driver Characteristics:		
Driver Type	Motor	Motor
Drive Arrangement	Vertical, Coupled	Vertical, Coupled
Non-Reverse Ratchets	Required	Required
Maximum Driver rpm	1,800	1,800
Motor Characteristics (when motor is driver type):		
Minimum Motor Horsepower	75	75
Inverter Duty Rated	No	No
Motor Voltage/Phase/Hertz	460/3/60	460/3/60
Enclosure Type	WP-1	WP-1

Tag Numbers	Injection Well No. 1	Injection Well No. 2
Service Factor	1.15	1.15
Motor Winding Heater (MWH)	Yes	Yes
Motor Winding Temperature Switch (TSH)	Yes	Yes
Field Quality Control Testing:		
Test Witnessing	Not Witnessed	Not Witnessed
Performance Test Level	Witnessed	Witnessed
Vibration Test Level	Witnessed	Witnessed

END OF SECTION

SECTION 11510

SAFETY EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: The following safety equipment:
   1. First aid kit.

1.02 REFERENCES

A. National Fire Protection Association.

B. Occupational Safety and Health Administration (OSHA).

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Shop drawings.

B. Product data:
   1. Submit manufacturer's product literature information for products specified.
   2. Manufacturer's installation instructions.

C. Samples.

D. Operation and maintenance data.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Show evidence that the firm has been engaged in producing such materials and products for at least 5 years and that the product submitted has a satisfactory performance record of at least 5 years.

B. Installer qualifications: Installer shall have 3 years experience in installing these materials for similar projects and shall be approved by the manufacturer prior to bidding of the project.

C. Regulatory requirements: As applicable, equipment of this Section shall comply with requirements of public agencies of the state where the project is located including OSHA, UL, NFPA.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver to the job site in manufacturer's original containers.

B. Delivery: After wet operations in building are completed.

C. Storage and protection: Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

D. Keep materials dry until ready for use.

E. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.

F. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS

2.01 FIRST AID KIT

A. Manufacturers: One of the following or equal:
   1. VWR Scientific, 56613-216.
   2. Fire Safety Source, 223UFAO.

B. Features/characteristics:
   1. Prefinished, wall-mounted metal cabinet.
   2. Standard medical supplies capable of serving up to 25 people.
   3. Meets OSHA requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturers' recommendations.

B. Install fixed equipment in accordance with manufacturer's instructions.

C. Replace any equipment found defective with new.

END OF SECTION

SECTION 13447

ELECTRIC MOTORIZED ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Electric motor-driven actuators for valves and gates as identified in the valves and gate schedule as EAM, FCV, OR EDR.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 15112 - Butterfly Valves.
      b. Section 15116 - Plug Valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. AWWA C504 - Rubber-Seated Butterfly Valves.
   2. AWWA C542 - Electric Motor Actuators for Valves and Slide Gates.

B. FM Global (FM).

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA:
   1. Type 4 enclosure in accordance with NEMA 250.
   2. Type 4X enclosure in accordance with NEMA 250.
   3. Type 7 enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Product data:
   1. Electrical ratings:
      a. Voltage and number of phases.
      b. Starting and running current.
      c. Voltage levels and source for control and status.
   2. Description of integral control interface.
   3. Integral and remote control station components.

4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
5. Gear ratios for both manual and motorized actuation.
6. Opening and closing directions.
7. Allowable starts per hour.
8. List of all included options and accessories.
9. Full travel times.
10. Gearbox data including gear ratio, and gearbox efficiency.
11. Affidavit in accordance with AWWA C542.

B. Shop drawings:
   1. Wiring diagrams:
      a. Include all options and expansion cards furnished with each actuator.
   2. Dimensioned drawings of each valve and actuator combination.
   3. Dimensioned drawings of each valve gearbox.
   4. Electric motor data.

C. Calculations: Submit the following for each valve/gate size and class:
   1. Operating torque calculations.
   2. Maximum torque calculations for seating and unseating.
   3. Maximum operating torque at starting and normal operation.
   4. Indicate factor of safety for all torque calculations.

D. Test reports:
   1. Factory test report and certificate.

E. Manufacturer's instructions:
   1. Include manufacturer's instructions, description of system operation, start-up data and troubleshooting check lists.

F. Operations and maintenance data:
   1. Include manufacturer's literature; cleaning procedures, replacement part lists, wiring diagrams, and repair data.
   2. Include a list of all configurable parameters, and the final values for each.
   3. List of recommended spare parts.
   4. List of special tools necessary for proper operation and/or maintenance.
   5. Exploded view drawings that illustrate all assemblies, sub-assemblies, and components.
   6. Routine test procedures for all electronic and electrical circuits.
   7. Troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.
   8. Certified factory and field-test results.

1.05 QUALITY ASSURANCE

A. Obtain required information from the valve/gate supplier, including but not limited to:
   1. Interface to gate or valve.
   2. Operating range:
      a. Quarter turn or multi-turn.
      b. Required turns for full travel on multi-turn applications.
   3. Direction of rotation for opening and closing.
   4. Maximum and normal torque requirements.

5. Additional sizing requirements indicated in the following Specifications:
    a. Section 15112.
    b. Section 15116.

B. All motorized, intelligent actuators shall be the product of a single manufacturer for all valve and gate applications on this project, regardless of gate or valve type, manufacturer, or supplier.

1.06 WARRANTY

A. Refer to Contract Documents.

1.07 SPARE PARTS

A. Provide the following spare parts (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
    1. Stem nut.
    2. Worm shaft subassembly.
    3. Drive sleeve subassembly.
    4. Complete actuator seal kit.
    5. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
    6. Encoder.
    7. Control module.

B. Provide 1 spare motor for each size motor furnished.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers for lines 4 inch and larger:
    1. EIM Corporation.

2.02 MANUFACTURED UNITS

A. Actuators for valves 4 inch and larger:
    1. Provide actuators complete and operable with all components and accessories required for operation.
    2. Power supply:
        a. Voltage and phases as indicated on the Valve and Gate Actuator Schedule.
        b. Valve or gate motion independent of power supply phase rotation.
    3. Size actuator to move gates or valves from full open to closed position within the time indicated in the Valve and Gate Actuator Schedule:
        a. If an operating time is not indicated on the Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load.
        b. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
    4. Control interface:
        a. Configuration:

1) Provide a non-intrusive, non-contacting interface for configuring all input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
    a) Configurable from a hand-held configuring tool or input devices on the actuator.

b. Local interface, integral to actuator:
    1) Selector switches:
        a) Local-stop-remote:
            (1) Motor actuator operation is prevented with the switch in STOP.
        b) Open-close:
            (1) Controls the valve when local-stop-remote is in LOCAL.
            (2) Spring return to center.
            (3) Configurable between maintained (actuator runs until end of travel, high torque, or a local-stop-remote is switched to STOP) and momentary (actuator stops when lever is released).

c. Remote control station - (VCP):
    1) Provide remote control stations for all actuators located more than 5 feet above finished floor/grade or where indicated on the Drawings or Valve and Gate Actuator Schedule:
        a) NEMA rating as listed in the Valve and Gate Actuator Schedule:
            (1) Where the rating is not listed, use NEMA Type 4X enclosures for non-hazardous areas, and explosion proof (XP) Class I Division 1 for hazardous areas.
        b) Local-stop-remote selector switch.
        c) Local mode control devices:
            (1) Operate valve when local-stop-remote integral to actuator is in REMOTE and local-stop-remote on remote control station is in LOCAL.
            (2) Open-stop-close maintained switch or OPEN, STOP and CLOSE pushbuttons where Maintained operation is indicated in the Valve and Gate Actuator Schedule.
            (3) Open-close spring-return switch or OPEN and CLOSE pushbuttons where momentary operation is indicated in the Valve and Gate Actuator Schedule.
        d) Pilots lights to indicate valve position:
            (1) FULLY OPEN.
            (2) FULLY CLOSED.

d. Control inputs:
    1) Capable of using 120 VAC input.
    2) Controls the valve when local-stop-remote is in REMOTE.
    3) Isolated inputs capable of operating from external control voltage source or internal power supply:
        a) Furnish control power supplies within the actuator.
    4) Provide the following inputs:
        a) OPEN.
        b) CLOSE.
        c) STOP.
        d) OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).

e. Status outputs:
    1) Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
    2) Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
        a) FULLY CLOSED.
        b) FULLY OPEN.
        c) Local-stop-remote in REMOTE position.
    3) All output contacts rated for 5 amps, 120 VAC and 24 VDC.
f. Analog input:
    1) Provide a 4-20 milliampere analog input for analog modulating valves when indicated on the Drawings.
    2) Modulate valve to maintain position based on analog input value.
    3) Maximum input impedance 250 ohms.
g. Analog output:
    1) Provide an isolated 4-20 milliampere analog outputs when indicated on the Drawings:
        a) Loop power sourced from the actuator power supply.
        b) Capable of driving into a load up to 500 ohms.
        c) Output proportional to process value(s) indicated on the Drawings.
        d) Valve or gate position.
        e) Operating torque.

2.03 FEATURES

A. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.

2.04 MATERIALS

A. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.

2.05 COMPONENTS

A. Motors:
    1. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
    2. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a minimum of 25 percent factor of safety:
        a. Design requirements for rubber-seated AWWA butterfly valves:
            1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542:
                a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.

b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.

b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
   1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C542.
   2) Design for the maximum torque and thrust running load over the full cycle.
   3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.

3. Capable of being removed and replaced without draining the actuator gear case.
4. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
5. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius:
   a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
   b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
6. Provide the following motor protection features:
   a. Jammed valve (no valve motion detected through a time delay).
   b. High motor temperature (sensed by embedded thermostats).
   c. High torque.
   d. Single phasing protection for 3-phase motors.

B. Enclosures:
   1. Actuator housing ratings as indicated in the Valve and Gate Actuator Schedule.
   2. Stainless steel external fasteners.
   3. Provide seals for each of the following areas:
      a. Between the terminal compartment and the internal electrical elements
      b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
   4. Provide the following minimum enclosure ratings:
      a. NEMA Type 4X for general applications.
      b. NEMA Type 7 certified by FM for Class I, Division 1, Groups C, D, E, F and G, for actuators installed in Class I, Division 1 and 2 areas.

C. Position sensing:
   1. Integral with valve actuator.
   2. Gearing: Intermittent type; bronze or stainless steel; grease lubricated; totally enclosed.
   3. Contacts: Heavy duty and silver-plated with wiping action or encoder wheel.
   4. Remote indication contacts: As indicated on the Drawings.

5. Switches: Adjustable; allowing for trip points from fully open to closed positions of valve travel; not subject to breakage or slippage due to over travel; permits visible verification of switch position without disassembly.
6. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
7. Valve range and position switch outputs field adjustable.

D. Torque sensing:
1. Capable of interrupting control circuit in both opening and closing when valve torque overload occurs.
2. Silver-plated contacts.
3. Graduated dials for both open and close directions of travel, each independently adjustable or 0-100 LTD display.
4. Positive means to limit adjustability to avoid exceeding actuator output torque capability with solid-state sensor embedded within the torque transducer.
5. Permits visible verification of switch position without disassembly.
6. Torque shutdown setting: 40 percent to 100 percent rated torque:
   a. Adjustable in 1 percent increments.
7. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
8. Independent of variations in frequency, voltage, or temperature.
9. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.

E. Manual actuators:
1. Hand wheel for manual operation:
   a. Maximum 80 pound pull on rim when operating gate or valve under maximum load.
   b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
      1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
      2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
2. Declutch lever: With padlock , capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.

F. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set:
1. Accurately cut to assure minimum backlash.

G. Bearings:
1. Anti-friction bearing with caged balls or rollers throughout.
2. Sealed-for-life type thrust bearings housed in a separate thrust base.

H. Drive bushing:
1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
2. Positioned in a detachable base of the actuator.

I. Lubrication:
   1. Provide totally enclosed actuator gearing with oil filled gear case suitable for operation at any angle.
      a. Suitable for standard SAE80EP gear oil.
      b. Actuators requiring special or exotic lubricants are not acceptable.
   2. Provide seals for all shafts.

2.06 SOURCE QUALITY CONTROL

A. Factory test:
   1. Test each actuator in the factory, and submit an individual test certificate for each actuator.
   2. Perform a high potential test and record the following information:
      a. Test voltage.
   3. Simulate a maximum and typical valve loads and record the following information:
      a. Current and power factor at maximum and set torque values.
      b. Torque as measured by the actuator.
      c. Actuator output speed or operating time.
   4. Performance testing: Conduct performance test for each actuator simulating valve operating torque from full-open to full-close and from full-close to full-open. The following information shall be recorded during each performance test:
      a. Torque at maximum torque setting.
      b. Current at maximum torque setting.
      c. Test voltage and frequency.
      d. Actuator output speed and operating time for full-open to full-close.
      e. Amperage draw on motors at breakaway and under normal operation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install actuators in accordance with manufacturer's instructions.

3.02 MOTORIZED ACTUATOR SCHEDULE

A. Provide all actuators required by the Drawings. Major process actuators are listed in the Valve and Gate Actuator Schedule. The schedule does not include all number and types of actuators required for the Project.

B. Abbreviations relating to type:
   1. BFV = Butterfly Valve.
   2. BV = Ball Valve.
   3. PV = Plug Valve.
   4. SG = Slide Gate.

C. Abbreviations relating to actuator type:
   1. O/C = Open and Close Service.
   2. MOD = Modulating Service.

D. Abbreviations relating to controls:
   1. MB = Modbus RTU (RS-485).
   2. NET = Manufacturer's proprietary network.
   3. A = Analog (4-20 mA) control, modulating duty.
   4. D = Discrete control, modulating duty.
   5. D-O/C = Discrete Open/Close.

END OF SECTION

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic design and performance requirements for mechanical equipment.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01600 - Product Requirements.
      b. Section 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 01756 - Commissioning and Process Start-up.
      e. Section 01770 - Closeout Procedures.
      f. Section 01782 - Operating and Maintenance Data.
      g. Section 03600 - Grouting.
      h. Section 05190 - Mechanical Anchoring And Fastening To Concrete And Masonry.
      i. Section 05120 - Structural Steel.
      j. Section 09960 - High-Performance Coatings.
      k. Section 10400 - Signage.
      l. Section 15052 - Common Work Results For General Piping.
      m. Section 15082 - Piping Insulation.
      n. Section 15958 - Mechanical Equipment Testing.
      o. Section 16950 - Field Electrical Acceptance Tests.
      p. Section 17950 - Testing Calibration and Commissioning.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
   1. 6001-E08 – Design and Selection of Components for Enclosed Gear Drives.

B. American Bearing Manufactures Association (ABMA) Standards:
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
   1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.
   2. A 48 - Standard Specification for Gray Iron Castings.
   3. A 125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
   4. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   6. A 194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   7. A 320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   8. A 536 - Standard Specification for Ductile Iron Castings.
   9. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   10. B 61 - Standard Specification for Steam or Valve Bronze Castings.
   11. B 62 - Standard specification for Composition Bronze or Ounce Metal Castings.
   12. B 505 - Standard Specification for Copper Alloy Continuous Castings.
   13. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   14. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   15. F 594 - Standard Specification for Stainless Steel Nuts.
   16. F 2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

E. Food and Drug Administration (FDA).

F. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting an specifying Concrete surface preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

G. Hydraulic Institute (HI).

H. NSF International (NSF).

1.03 DEFINITIONS

A. Special tools: Tools that have been specifically made for use on unit of equipment for assembly, disassembly, repair, or maintenance.

B. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.

C. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.

D. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.

E. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.

F. Rotational speed: Same as rotational frequency.

G. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

H. Critical speed: Same as critical frequency.

I. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.

J. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 SYSTEM DESCRIPTION

A. General:
   1. Product requirements as specified in Section 01600.
   2. Materials in contact with drinking water as specified in Section 01600.
   3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions as specified in this Section.
   4. Provide equipment and parts that are suitable for stresses, which may occur during fabrication, transportation, erection, and operation.
   5. Provide equipment that has not been in service prior to delivery, except as required by tests.
   6. Like parts of duplicate units are to be interchangeable.
   7. When 2 or more units of equipment for the same purpose are required, provide products of same manufacturer.
   8. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
   9. When necessary, modify manufacturer's standard product to conform to specified requirements or requirements indicated on the Drawings and contained in Laws and Regulations.

B. Material requirements:
   1. Materials: Suitable for superior corrosion resistance and for services under conditions normally encountered in similar installations.
   2. Dissimilar metals: Separate contacting surfaces with dielectric material.

C. Power transmission systems:
   1. Power transmission equipment: V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a minimum service factor of 1.5:
      a. Apply 1.5 service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.

b. Apply service factors higher than 1.5 when recommended for continuous 24 hour per day operation and shock loadings in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.
c. When manufacturer recommends service factor greater than 1.5, manufacturer's recommendation takes precedence.

D. Vibration:
1. Resonant frequency:
a. For single speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
b. For variable speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
2. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958.

E. Equipment mounting and anchoring:
1. Mount equipment on cast iron or welded steel bases with structural steel support frames.
a. Utilize continuous welds to seal seams and contact edges between steel members.
b. Grind welds smooth.
2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01612, and other loads as required for proper operation of equipment.
5. Anchorage of equipment to concrete or masonry:
a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190.
c. Provide bolt sleeves around cast-in anchor bolts for heavy equipment.
1) Adjust bolts to final location and fill sleeve with polyurethene foam.
6. Anchorage of equipment to metal supports: Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.

F. Seismic design:
1. Design equipment anchorage and related details for seismic design criteria as specified in Section 01612.
2. For equipment with operating weight of 400 pounds and greater that is supported 4 feet or less above the floor and all equipment that is supported higher than 4 feet above the floor, provide calculations for:

a. The operating weight and location of the centroid of mass for the equipment.
b. Forces and overturning moments.
c. Shear and tension forces in equipment anchorages, supports, and connections.
d. The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.

G. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

1.05 SUBMITTALS

A. Product data:
1. For each item of equipment:
a. Design features.
b. Load capacities.
c. Efficiency ratings.
d. Material designations by UNS alloy number or ASTM Specification and Grade.
e. Data needed to verify compliance with the Specifications.
f. Catalog data.
g. Name plate data.
h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
2. Gear reduction units:
a. Engineering information in accordance with applicable AGMA standards.
b. Gear mesh frequencies.

B. Shop drawings:
1. Drawings for equipment:
a. Drawings that include outline drawings, cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer based controls.
5. Recommended or normal operating parameters such as temperatures and pressures.
6. Alarm and shutdown set points for all controls furnished.

C. Calculations:
1. Calculations and other information to substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design strength requirements and seismic design criteria specified in Section 01612.
2. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.

3. Calculations and other information to substantiate that operating rotational frequencies meet the requirements of this Section.
4. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
    a. Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
    b. Results of analysis including first and second critical frequencies of system components and complete system.
5. Calculations shall be signed and stamped by a civil or structural engineer registered to practice in the state where the Project is located.

D. Quality control submittals:
1. Source quality control reports and certified test data as specified in Section 15958.
2. Submit factory test reports before shipment.
3. Certified static and dynamic balancing reports for rotating equipment.
4. Field quality control reports and test data as specified in Section 15958.
5. Submit material test reports a specified in the equipment sections.

E. Operation and maintenance manuals:
1. As specified in Section 01782.
2. Submit prior to training of Owner's personnel.
3. Make available at project site complete copy of manuals for use by field personnel and Engineer during commissioning and process start-up of equipment.
4. Include manufacturer and model number of every bearing; include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
5. Include motor rotor bar pass frequencies.

F. Commissioning and process start-up submittals: As specified in Section 01756.

G. Project closeout documents: As specified in Section 01770.

1.06 QUALITY ASSURANCE

A. Manufacturer's field service:
1. Furnish services of authorized representative specially trained in installation of equipment:
    a. Visit project site and perform tasks necessary to certify installation as specified in Section 01756.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Equipment: Pack in boxes, crates, or otherwise protect from damage and moisture, dust, or dirt during shipment, handling, and storage.
2. Bearings: Separately pack or otherwise suitably protect during transport.
3. Spare parts: Deliver in boxes labeled with contents, equipment to which spare parts belong, and name of Contractor.

B. Storage:
1. Equipment having bearings:

a. Store in enclosed facilities.
b. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.

2. Gear boxes: Oil filled or sprayed with rust preventive protective coating.

C. Protection:
1. Equipment: Protect equipment from deleterious exposure.
2. Painted surfaces: Protect against impact, abrasion, discoloration, and other damage.

1.08 SEQUENCING AND SCHEDULING

A. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place when concrete is placed.

B. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. Commissioning and process start-up submittals: As specified in Section 01756.
1. Perform general commissioning and process start-up and testing procedures after operation and maintenance manuals for equipment have been received and accepted.
2. Conduct functional testing of mechanical or electrical systems when each system is substantially complete and after general Installation testing procedures have been successfully completed.
3. Functional testing requirements as specified in Sections 01756, 15958, 16950, and 17950 and the equipment sections.

1.09 MAINTENANCE

A. Special tools:
1. When specified, provide special tools required for operation and maintenance.
2. Mark or tag and list such tools in maintenance and operations instructions. Describe use of each tool.

B. Spare belts:
1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
a. Where 2 or more belts are involved, furnish matched sets.
b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
c. Package in boxes labeled with identification of contents.

C. Spare parts:
1. Assume responsibility until turned over to Owner.
2. Store in enclosed facilities.
3. Furnish itemized list and match identification tag attached to every part.
4. List parts by generic title and identification number.
5. Furnish name, address, and telephone number of supplier and spare parts warehouse.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials in contact with drinking water as specified in Section 01600.

B. Ferrous materials:
   1. Steel for members used in fabrication of assemblies: ASTM A 36.
   2. Iron castings: ASTM A 48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
   3. Ductile iron castings: ASTM A 536, Grade 65-45-12, free from flaws and imperfections.
   4. Galvanized steel sheet: ASTM A 653, minimum 0.0635 inch (16 gauge).
   5. Expanded metal: ASTM A 36, 13 gauge, 1/2-inch flat pattern expanded metal.

C. Nonferrous materials:
   1. Stainless steel: Type 304 or 316 as specified. Provide L grade where welding required.
   2. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833, C89520, or C92200 in accordance with ASTM B 61, B 62, B 505, or B 584, when not specified otherwise.
   3. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, [C89520, C92200, or C93700 in accordance with ASTM B 61, B 62, B 505, or B 584, when not specified otherwise.

D. Dielectric materials for separation of dissimilar metals:
   1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials.

E. Non-shrink grout: As specified in Section 03600.

2.02 FASTENERS

A. General:
   1. Material: As specified in the individual specifications.
   2. Where fasteners are specified to be galvanized, shall be galvanized in accordance with ASTM A 153 or ASTM F 2329.

B. Mechanical anchors:
   1. As specified in Section 01612 and Section 05190.

C. High-strength fasteners:
   1. As specified in Section 05120.

D. Flange bolts:
   1. As specified in Section 15082.

E. Mechanical assembly fasteners:
   1. Stainless steel:
      a. High Temperature Service or High Pressure Service.

1) Bolts: ASTM A 193, Grade B8 (304 SST) or Grade B8M (316 SST), Class 1, heavy hex.
2) Nuts: ASTM A 194, Grade 8, heavy hex.
3) Washers: Alloy group matching botls and nuts.

b. Low Temperature Service:
1) Bolts: ASTM A 320, Grade B8 (304 SST) or Grade B8M (316 SST), Class 1, heavy hex.
2) Nuts: ASTM A 194, Grade 8 (304 SST) or Grade B8M (316 SST), heavy hex.
3) Washers: Alloy group matching bolts and nuts.

c. General service:
1) Bolts: ASTM F 593, Alloy group 1 (304 SST) or Alloy group 2 (316 SST).
2) Nuts: ASTM F 594, Alloy group 1 (304 SST) or Alloy group 2 (316 SST).
3) Washers: Alloy group matching bolts and nuts.

2. Carbon Steel.

2.03 SHAFT COUPLINGS

A. General:
1. Type and ratings: Provide nonlubricated type, designed for not less than 50,000 hours of operating life.
2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.
3. Use: Use of couplings specified in this Section does not relieve Contractor of responsibility to provide precision alignment of driver-driven units as required by equipment manufacturer and alignment criteria specified elsewhere in this Section.

B. Shaft couplings - close coupled: Shaft couplings for close coupled electric motor driven equipment 1/2 horsepower or larger and subject to sudden torque reversals or shock loading:
1. Manufacturers: One of the following or equal:
a. T.B. Woods, Dura-Flex, L-Jaw C-Jaw or G-Jaw.
b. Lovejoy, S-Flex.
2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
3. Manufacture flexible component of coupling from synthetic rubber, or urethane.
4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
5. Do not allow metal-to-metal contact between driver and driven equipment.
6. Examples of loads where sudden torque reversals may be expected:
a. Reciprocating pumps, blowers, and compressors.
b. Conveyor belts.
c. Reversing equipment.

C. Shaft couplings - direct connected: Shaft couplings for direct connected electric motor driven equipment 1/2 horsepower or larger and subject to normal torque, non-reversing applications:
1. Manufacturers: One of the following or equal:
a. Rexnord - Falk.

b. T.B. Woods, Dura-Flex, Sure-Flex or Form-Flex.
2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
3. Provide flexible connecting element of rubber and reinforcement fibers.
4. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings: Where cartridge type mechanical seals or non-split seals are specified, provide a spacer type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.

E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer.

2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

A. General:
1. Unless otherwise noted in the equipment section, provide cartridge type, double mechanical shaft seals for pumps.
2. Provide a stuffing box large enough for a double mechanical seal.
3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
   a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
   b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
   c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
   d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water- see Carollo typical detail # M262).
   e. Double seal applications: Plan 54 (External seal water- see Carollo typical detail # M262).

B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
1. Wastewater, water, and sludge applications:
   a. Asbestos free.
   b. PTFE (Teflon) free.
   c. Braided graphite.
   d. Manufacturers: One of the following or equal:
      1) Chesterton, 1400.
      2) John Crane Inc., equivalent product.
2. Drinking water service:

a. Approved by the FDA.
b. As specified in Section 01600.
c. Asbestos free.
d. Material: Braided PTFE (Teflon).
e. Manufacturers: One of the following or equal:
1) Chesterton, 1725.
2) John Crane, Inc., equivalent product.

C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
1. Provide seal types meeting the following requirements:
a. Balanced hydraulically.
b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
c. O-ring: Viton 747.
d. Gland: Type 316L stainless steel.
e. Set screws: Type 316L stainless steel.
f. Faces: Reaction bonded, Silicon Carbide.
g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
2. Cartridge type single mechanical: Manufacturers: One of the following or equal:
a. Chesterton, S10.
b. John Crane, 5610 Series.
3. Cartridge type double mechanical: Manufacturers: One of the following or equal:
a. Chesterton, S20.
b. John Crane, 5620 Series.
4. Split face single mechanical: Manufacturers: One of the following or equal:
a. Chesterton, 442.
b. John Crane, 3740.

2.05 GEAR REDUCTION UNITS

A. Type: Helical or herringbone, unless otherwise specified.

B. Design:
1. Made of alloys treated for hardness and for severe service.
2. AGMA Class II service:
a. Use more severe service condition when such is recommended by unit's manufacturer.
3. Cast iron housing with gears running in oil.
4. Anti-friction bearings.
5. Thermal horsepower rating based on maximum horsepower rating of prime mover not actual load.
6. Manufactured in accordance with applicable AGMA standards.

C. Planetary gear units are not to be used.

2.06 BELT DRIVES

A. Sheaves:
   1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
   2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
   3. Statically balanced for all; dynamically balanced for sheaves that operates at peripheral speed of more than 5,500 feet per minute.
   4. Key bushings to drive shaft.

B. Belts: Anti-static type when explosion-proof equipment or environment is specified.

C. Manufacturers: One of the following or equal:
   1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
   2. T.B. Wood's, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.07 BEARINGS

A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

B. Oil lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash type system:
   1. Size oil lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degree Fahrenheit above the maximum design temperature as specified in Section 01610.
   2. Provide an external oil cooler when required to satisfy the specified operating conditions.
      a. Provide air cooled system if a water-cooling source is not indicated on the Drawings.
      b. Equip oil cooler with a filler pipe and external level gauge.

C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
   1. Lubrication lines and fittings:
      a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
      b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
      c. Use standard hydraulic type grease supply fittings:
         1) Manufacturers: One of the following or equal:
            a) Alenite.
            b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours:
   1. Higher ratings, when specified in other Sections, supersede preceding requirement.

2.08 SAFETY GUARDS

A. Drive assemblies: Enclose sprockets, belts, drive chains, gearings, couplings, and other moving parts on drive assemblies in safety enclosures that are in compliance with applicable Laws and Regulations.

B. Shafts: Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.

C. Hot surfaces: Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level; insulation thickness such that temperature is below 120 degrees Fahrenheit; cover insulation with moisture-proof protective jacket; insulation Type 3 and cover Type 5 as specified in Section 15082.

D. Guard requirements:
   1. Allow visual inspection of moving parts without removal.
   2. Allow access to lubrication fittings.
   3. Prevent entrance of rain or dripping water for outdoor locations.
   4. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.

E. Materials:
   1. Sheet metal: Carbon steel, 12 gauge minimum thickness, hot-dip galvanized after fabrication.
   2. Fasteners: Type 304 stainless steel.

2.09 SPRING VIBRATION ISOLATORS

A. Design requirements:
   1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.
   2. Use steel coil springs.
   3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612.

B. Performance requirements: Minimum spring deflection of 1 inch under static load and capable of limiting transmissability to 15 percent maximum at design operating load.

C. Manufacturers: One of the following or equal:
   1. California Dynamics Corporation, Type RJSD.
   2. Mason Industries, equivalent product.

D. Materials:
   1. Fabricate isolators using welded steel or shatterproof ductile iron in accordance with ASTM A 536 Grade CS-45-12.
   2. Spring steel: ASTM A 125.

2.10 WARNING SIGNS

A. Provide for equipment that starts automatically or remotely.

B. Material and size: Metal as specified in Section 10400.

C. Colors: Black lettering on yellow background.

D. Text: As specified in Section 10400.

2.11 CHEMICAL DIFFUSERS

A. Design requirements:
   1. As indicted on the drawings.

B. Manufacturers: One of the following or equal:
   1. SAF-T-Flo.

2.12 FABRICATION

A. Structural steel members: As specified in Section 05120.

B. Nameplates:
   1. Engraved or stamped on Type 304 stainless steel and fastened to equipment at factory in an accessible and visible location.
   2. Indicate following information as applicable:
      a. Manufacturer's name.
      b. Equipment model number and serial number.
      c. Maximum and Normal rotating speed.
      d. Horsepower.
      e. Rated capacity.
      f. Service class per applicable standards.
   3. Nameplates for pumps: Include:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   4. Gear reduction units: Include:
      a. AGMA Class of service.
      b. Service factor.
      c. Input and output speeds.

C. Bolt holes in equipment support frames:
   1. Do not exceed bolt diameter by more than 25 percent, up to limiting maximum diameter oversize of 1/4 inch.

D. Shop finishing:
   1. Provide factory and field coating as specified in Section 09960.
      a. Finish painting of motors: Shop finish paint with manufacturer's standard coating, unless otherwise specified in Section 09960.

2.13 SOURCE QUALITY CONTROL

A. As specified in Section 15958 for testing requirements and the individual equipment sections of the Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect all components for shipping damage, conformance to specifications, and proper torques and tightness of fasteners.

3.02 PREPARATION

A. Metal work embedded in concrete:
   1. Accurately place and hold in correct position while concrete is being placed.
   2. Clean surface of metal in contact with concrete immediately before concrete is placed.

B. Concrete surfaces designated to receive non-shrink grout:
   1. Heavy sandblast concrete surface in contact with non-shrink grout.
   2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
   3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

C. Field measurements:
   1. Prior to fabrication of equipment, take measurements for installation of equipment and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's installation instructions and recommendations.

B. Lubrication lines and fittings:
   1. Lines from fittings to point of use: Support and protect.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

C. Alignment of drivers and equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
   2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
      a. Maximum total coupling offset (not the per plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).

b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.

3. Use reverse-indicator arrangement dial type or laser type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
   a. Allow minimum 48 hours for grout to harden.
   b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   c. Correct alignment as required.
6. After operational testing is complete, dowel motor or drivers and driven equipment.
   a. Comply with manufacturer's instructions.

D. Grouting under equipment bases, baseplates, soleplates, and skids with non-shrink grout:
   1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03600.
   2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
   3. Install non-shrink grout only after:
      a. Equipment is leveled and in proper alignment.
      b. Piping connections are complete and in alignment with no strain transmitted to equipment.
   4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
   5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
      a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
      b. Use suitable number and size of jack screws.
      c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
      d. Jack screw threads that will be in contact with non-shrink grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent non-shrink grout from bonding to threads.
      e. Place non-shrink grout.
      f. Cure non-shrink grout.
      g. After non-shrink grout has been cured, remove jack screws and material used to prevent bond to non-shrink grout.
         1) Provide jack screws to Owner for future use.
      h. Tighten equipment anchors in accordance with equipment manufacturer requirements.
      i. Fill holes where jack screws have been removed with non-shrink grout.
      j. Cure non-shrink grout in repaired areas.

6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims, using procedure defined below:
    a. Wrap wedges and shims that contact non-shrink grout with multiple layers of tape or other material, acceptable to Engineer, to prevent non-shrink grout from bonding.
    b. Place non-shrink grout.
    c. Cure non-shrink grout.
    d. Remove wedges or shims.
    e. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
    f. Fill voids where wedges and shims have been removed with non-shrink grout.
    g. Cure non-shrink grout in repaired areas.
7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
    a. Metal in contact with grout: Grit blast to white metal finish.
    b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint and other material that will reduce bond.
8. Preparation of concrete equipment foundation for grouting:
    a. Rough concrete surfaces in contact with non-shrink grout to ICRI CDP-6 surface profile or rougher.
    b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
    c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
    d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.

9. Forms and headboxes:
    a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
    b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
    c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
10. Grout placement requirements:
    a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising.
        1) Conform to non-shrink grout manufacturer’s temperature requirements.
    b. Pour non-shrink grout using head box.
    c. Keep level of non-shrink grout in head box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment in grout.
    d. Non-shrink grout shall flow continuously from head box to other side of forms without trapping air or forming voids.
    e. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove entrapped air.

f. After non-shrink grout sets, remove forms and trim grout at 45 degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
g. Water cure non-shrink grout continuously for a minimum of 7 days as specified in Section 03600.

E. Grouting under equipment bases, baseplates, soleplates, and skids with non-shrink epoxy grout:
1. If indicated on the Drawings, grout with non-shrink epoxy grout as specified in Section 03600.
2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignments.
3. Install non-shrink epoxy grout only after:
a. Equipment is level and in proper alignment.
b. Piping connections are complete and in alignment with no strain transmitted to equipment.
4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
b. Use suitable number and size of jack screws.
c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
d. Jack screw threads that will be in contact with non-shrink epoxy grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent non-shrink epoxy grout from bonding to threads.
e. Place non-shrink epoxy grout.
f. Remove jack screw and material used to prevent bond to non-shrink epoxy grout.
1) Provide jack screws to Owner for future use.
g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
h. Fill holes where jack screws have been removed with non-shrink epoxy grout.
6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims, using procedure defined below:
a. Wedges and shims that contact non-shrink epoxy grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent non-shrink epoxy grout from bonding.
b. Place non-shrink epoxy grout.
c. After minimum of 2 days, remove wedges or shims.
d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
e. Fill voids where wedges and shims have been removed with non-shrink epoxy grout.
7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
a. Metal in contact with grout: Grit blast to white metal finish.

b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint and other material that will reduce bond.

8. Preparation of concrete equipment foundation for grouting:
   a. Rough concrete surfaces in contact with non-shrink epoxy grout to ICRI CDP-6 surface profile or rougher.
   b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
   c. Concrete surface in contact with non-shrink epoxy grout shall be dry.

9. Forms and headboxes:
   a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
   b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
   c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
10. Grout placement requirements:
   a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising.
      1) Conform to non-shrink epoxy grout manufacturer's temperature requirements.
   b. Pour non-shrink epoxy grout using head box.
   c. Keep level of non-shrink epoxy grout in head box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment in grout.
   d. Non-shrink epoxy grout shall flow continuously from head box to other side of forms without trapping air or forming voids.
   e. Vibrate, rod, or chain non-shrink epoxy grout to facilitate grout flow and remove entrapped air.
   f. After non-shrink epoxy grout sets, remove forms and trim grout at 45 degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.

F. Special techniques: Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.

G. Tolerances:
   1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.

H. Warning signs: Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.04 FIELD QUALITY CONTROL

A. Test equipment as specified in Section 15958 and the individual equipment section of the Specifications.

3.05 COMMISSIONING AND PROCESS START-UP

A. Perform commissioning and process start-up: As specified in Section 01756.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic piping materials and methods.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01140 - Work Restrictions.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 01757 - Disinfection.
      d. Section 09960 - High-Performance Coatings.
      e. Section 15061 - Pipe Supports.
      f. Section 15062 - Preformed Channel Pipe Support System.
      g. Section 15063 - Non-Metallic Pipe Support System.
      h. Section 15210 - Cast Iron Soil Pipe: ASTM A 74.
      i. Section 15211 - Ductile Iron Pipe : AWWA C151.
      j. Section 15230 - Plastic Piping and Tubing.
      k. Section 15234 - Polyethylene (PE) Pipe: ASTM D 2513.
      l. Section 15281 - Copper Water Tube-Seamless, ASTM B 88.
      m. Section 15286 - Stainless Steel Pipe.
      n. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
   1. C105 – Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.

C. ASTM International (ASTM):
   1. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

2. A 194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
3. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
4. A 563 – Standard Specification for Carbon and Alloy Steel Nuts.
5. F 37 - Standard Test Methods for Sealability of Gasket Materials.

D. California Health and Safety Code.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
2. 372 - Drinking Water System Components - Lead Content.

1.03 DEFINITIONS

A. Buried pipe: Pipe that is buried in the soil, or cast in a concrete pipe encasement that is buried in the soil.

B. Exposed pipe: Pipe that is located above ground, or pipe that is located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground piping: Piping actually buried in soil or cast in concrete that is buried in soil.

D. Underwater piping: Piping below tops of walls in basins or tanks containing water.

E. Wet wall: Wall with water on at least 1 side.

1.04 SUBMITTALS

A. Product data:
1. Escutcheons.
2. Flange bolts.
3. Gaskets.
4. Grooved joint couplings and fittings.
5. Link -type seals.
6. Certifications of compliance with reference standard for lead limits.

B. Calculations:
1. Materials in contact with drinking water provide calculations in accordance with NSF 372.

C. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756.

D. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

B. Manufacturers: One of the following or equal:
   1. Dearborn Brass Company, Model Number 5358.
   2. Keeney Manufacturing Company, Model Number 102 or Number 105.

2.03 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Assemble links solely with stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.

B. Manufacturers: One of the following or equal:
   1. Calpico, Incorporated.
   2. Pipeline Seal and Insulator, Inc., Link-Seal.

2.04 FLANGE BOLTS

A. Ductile iron pipe:
   1. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures and where pressures do not exceed 150 pounds per square inch shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
   2. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures where the pressures exceed 150 pounds per square inch shall be alloy steel, ASTM A 193, Grade B7 for bolts and in accordance with ASTM A 194, Grade 2H for nuts.
   3. Bolts and nuts for ductile iron pipe flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
   4. Bolts and nuts for buried ductile iron pipe flanges shall be [Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
   5. Provide a washer for each nut. Washer shall be of the same material as the nut.
   6. Nuts shall be Heavy hex-head.
   7. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
   8. Tap holes for cap screws or stud bolts when used.

B. Plastic pipe:
   1. Bolts and nuts for flanges on plastic pipe located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon

steel, in accordance with ASTM A 307, Grade B for bolts and in accordance with ASTM A 563, Grade A for nuts.

2. Bolts and nuts for flanges on plastic pipe submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures and plastic pipe carrying corrosive chemicals shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
3. Provide a washer for each nut. Washer shall be of the same material as the nut.
4. Nuts shall be Heavy hex-head.
5. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
6. Tap holes for cap screws or stud bolts when used.

C. Steel pipe:
1. Bolts and nuts for ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B for bolts and in accordance with ASTM A 563, Grade A for nuts.
2. Bolts and nuts for ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges located indoors, outdoors above ground, or in dry vaults and structures in accordance with ASTM A 193, Grade B7 for bolts and in accordance with ASTM A 194, Grade 2H for nuts.
3. Bolts and nuts for flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
4. Provide a washer for each nut. Washer shall be of the same material as the nut.
5. Nuts shall be Heavy hex-head.
6. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
7. Tap holes for cap screws or stud bolts when used.

D. Lubricant for stainless steel bolts and nuts:
1. Chloride-free.
2. Manufacturers: One of the following or equal:
   a. Huskey FG-1800.

2.05 GASKETS

A. General Fluid and Chemical Compatibility: Gaskets and seal materials shall be as follows:

Liquid or Chemical Service	Acceptable Elastomers	Full Face Flange Gaskets, Garlock Style	Comment
Brine	EPDM	8314	
Water – Reclaimed	EPDM/Viton	8314	
Water – Softened	EPDM/Nitrile	8314	
Sodium Hypochlorite	PTFE	Stress Saver 370	
Reagent Waste			

B. Gaskets for non-steam cleaned ductile iron and steel piping:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
   2. Gasket material:
      a. Chloramine resistant elastomer with minimum Shore A hardness value of 85.
      b. Reinforcement: Per manufacturer's recommendations.
      c. Gaskets for services, including raw, settled, filtered, finished, backwash, and recovered water, shall be EPDM or Viton suitable for contact with chloraminated water.
      d. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Style 8314.
      b. John Crane, similar product.

C. Gaskets for non-steam cleaned grooved end ductile iron and steel piping:
   1. Suitable for pressures equal to the encapsulating coupling or flange adapter.
   2. Material: Pressure responsive elastomer.
      a. Ductile iron piping: FlushSeal® type.
         1) Halogenated Butyl: Grade M; for temperatures to 200 degrees Fahrenheit.
         2) Nitrile: Grade S; for temperatures to 180 degrees Fahrenheit.
      b. Steel piping:
         1) EPDM: Grade E; for temperatures to 230 degrees Fahrenheit.
         2) EPDM-HP: Grade EHP, for temperatures to 250 degrees Fahrenheit.
         3) Nitrile: Grade T, for temperatures to 180 degrees Fahrenheit.
   3. Gaskets shall be verified as suitable for the intended service.
      a. Temperature ratings may vary depending on the fluid/media.
   4. Manufacturers: Gaskets shall be of the same manufacturer as the encapsulating couplings/flange adapters.
      a. Victaulic Company.

D. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
   2. Material: 0.125-inch thick Viton rubber.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.

E. Gaskets for flanged joints in ductile iron or steel water piping:
   1. Suitable for hot or cold water, pressures equal and less than 150 pounds per square inch gauge, and temperatures equal and less than 160 degrees Fahrenheit.
   2. Material:

a. Chloramine resistant elastomer with minimum Shore A hardness value of 85.
b. Reinforcement: Per manufacturer's recommendations.
c. Gaskets for services, including raw, settled, filtered, finished, backwash, and recovered water, shall be EPDM or Viton suitable for contact with chloraminated water.
d. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.

3. Manufacturers: One of the following or equal:
a. Garlock.
b. John Crane, similar product.

F. Provide gaskets suitable for the specific fluids and pressure and temperature conditions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of existing conditions:
1. Locate and expose existing structures, piping, conduits, and other facilities and obstructions that may affect construction of underground piping before starting excavation for new underground piping and appurtenances.
2. Verify sizes, elevations, locations, and other relevant features of existing facilities and obstructions. Determine conflicts for the construction of the new underground piping and appurtenances.
3. Make piping location and grade adjustments to resolve conflicts between new piping and existing facilities and obstructions.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
1. Provide Manufacturer's Certificate of Source Testing.
2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
a. Functional Testing: for watertight installations only.

3.03 INSTALLATION

A. General:
1. Piping drawings:
a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.

1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.

2. Piping alternatives:
   a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
   b. Alternative pipe ratings:
      1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
      2) Piping of different material may not be substituted in lieu of specified piping.
   c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
   d. For grooved joints, use couplings, flange adapters, and fittings of the same manufacturer.
      1) The grooved joint manufacturer's factory trained representative shall provide on-site training for Contractor's field personnel in
      2) The representative shall periodically visit the jobsite and review Contractor is following best recommended practices in grooved product installation.
      3) A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).
   e. For flanged joints, where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.
3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
   1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
   2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
      a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
      b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
      c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
      d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
      e. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.
   3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
   4. Core drilled openings:

a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
2) Slope digester gas piping to drip traps or low-point drains at a minimum of 1/2 inch per foot where condensate flows against the gas, or at a minimum of 1/4 inch per foot where condensate flows with gas.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
3. Support piping: As specified in Sections 15061, 15062, and 15063:
a. Do not transfer pipe loads and strain to equipment.
4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
5. Assemble piping without distortion or stresses caused by misalignment:
a. Match and properly orient flanges, unions, flexible couplings, and other connections.
b. Do not subject piping to bending or other undue stresses when fitting piping.
c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
e. Alter piping assembly to fit, when proper fit is not obtained.
f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
3. Laying piping:
a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
b. Place piping with top or bottom markings with markings in proper position.

c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.

4. Concrete encase all buried pipe installed under concrete slabs or structures.

E. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
2. Install plug valves as air bleeder cocks at high points in piping.
a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09960.

F. Condensate in digester gas piping:
1. Slope digester gas piping to drip traps or low-point drains at minimum 1/2 inch per foot where condensate flows against the gas or 1/4 inch per foot where condensate flows with gas.
2. Install tapered filler pieces between flanges at high points of straight runs to provide for slope reversals.
a. Do not subject piping to high stresses in order to change direction.
3. Provide pipe taps, threaded nipples, and 1-inch plug valves at low points in concrete utility boxes with lids.

G. Restraining piping:
1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
b. When piping is aboveground or underwater, use mechanical or structural restraints.
c. Determine thrust forces by multiplying the nominal cross sectional area of the piping by design test pressure of the piping.
2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
3. Place concrete thrust blocks against undisturbed soil.
4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
5. Provide underground mechanical restraints where specified in the Piping Schedule.

H. Connections to existing piping:
1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:

a. Protect domestic water/potable water supplies from contamination:
1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
2) Provide devices approved by Owner of domestic water supply system to prevent flow from other sources into the domestic supply system.

2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

I. Connections to in-service piping:
1. As specified in Section 01140.

J. Connections between ferrous and nonferrous metals:
1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
2. Nonferrous metals include aluminum, copper, and copper alloys.

K. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.04 CLEANING

A. Piping cleaning:
1. Upon completion of installation, clean piping interior of foreign matter and debris.
2. Perform special cleaning when required by the Contract Documents.

B. Cleaning potable water piping:
1. Flush and disinfect potable water piping as specified in Section 01757.

C. Cleaning and drying of dry chlorine gas or liquid chlorine piping:
1. Coordinate with Owner and attend a pre-cleaning meeting with Owner before cleaning chlorine piping.
2. Work with Owner during cleaning and conform to plant operational and shut down constraints.
3. Clean chlorine pressure piping in accordance with the requirements of the Chlorine Institute-Pamphlet 6 and meet the following requirements.
4. Do not put water into any of the chlorine gas or liquid piping.
5. Blow chlorine piping clean of loose debris with compressed air at 4,000 fpm.
6. Clean chlorine piping by pulling clean cloths saturated with an approved solvent through piping:
a. Do not use hydrocarbons or alcohols that may react with chlorine.
b. Use solvents in accordance with manufacturer's safety recommendations to avoid serious physiological effects.
c. Remove all dirt and debris of any nature from the chlorine lines.

7. Disassemble and clean valves and equipment that have oil residues before installation.
8. Dry piping immediately before effecting final connections for service.
    a. Keep piping sealed to prevent moisture from entering chlorine piping.
    b. Supply compressors, air dryers, and dew point testing equipment necessary to dry and test for dryness the new chlorination system piping.
    c. Drying procedure:
        1) Pass dry commercial grade nitrogen gas that has a dew point of minus 40 degrees Fahrenheit or less through the piping until exhausted air at three Engineer-approved locations has a dew point of minus 40 degrees Fahrenheit.
        2) Confirm dew point with a hygrometer.
        3) Allow several hours for drying piping.
        4) Re-dry the chlorine piping system in the event subsequent work opens any part of the system to the atmosphere.

D. Cleaning and drying chlorine gas vacuum piping:
1. Blow pipe clean of loose debris with instrument-grade clean and dry compressed air.
2. Ensure that pipe is open and not valved off at the end of the section to be cleaned so that pipe does not become pressurized. DO NOT PRESSURIZE PVC WITH COMPRESSED AIR.
3. Do not flush chlorine gas vacuum piping with water.
4. After cleaning, purge air out with commercial grade dry nitrogen that has a dew point of minus 40 degrees Fahrenheit or less.

E. Cleaning chlorine piping:
1. Clean chlorine piping by pulling clean cloths saturated an approved solvent through piping:
    a. Do not use hydrocarbons or alcohols that may react with chlorine.
    b. Use solvents in accordance with manufacturer's safety recommendations to avoid serious physiological effects.
2. Disassemble and clean valves and equipment that have oil residues before installation.
3. Dry piping immediately before effecting final connections for service.
    a. Keep piping kept sealed to prevent moisture from entering chlorine piping.
    b. Drying procedure shall be as follows:
        1) Pass steam through piping from the high end until piping is thoroughly heated. While steaming, allow condensate and foreign matter to drain out.
        2) Stop steaming and drain pockets and low points.
        3) While piping is hot, blow dry air through piping until piping is dry.
            a) Use dry air with a dew point of minus 40 degrees Fahrenheit or below.
        4) Continue blowing dry air through piping until exhausted air has a dew point of minus 30 degrees Fahrenheit or below.
        5) Allow several hours for drying piping.

3.05 PIPING SCHEDULE

PIPING SCHEDULE										
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
D	Drain									
	Underground (below foundations)	All	DIP	CL 53	15211	MJ	30 psig/ HH	CM	PEE	
	Underground (yard)	<4	CPVC	Sch 80	15259	SW	30 psig/HH	None	None	
	Aboveground	All	DIP	CL 53	15211	FL	30 psig/ HH	CM	HPC	
IWS/PTW	Reclaimed Water									
	Underground	>4	PVC	CL 125	15244	MJ	125 psig/ HH	None	None	AWWA C900/905. Restrained joints for pressure lines
	Aboveground	>4	DIP	CL 53	15211	FL	125 psig/ HH	CM	HPC	
BRN	Brine									
	Underground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	None	
	Aboveground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	HSEP	
BF	Groundwater									
	Underground	>3	PVC	CL 125	15244	MJ	125 psig/ HH	None	None	AWWA C900/905. Restrained joints for pressure lines
	Aboveground	>3	DIP	CL 53	15211	FL	125 psig/ HH	CM	HPC	
OF	Reclaimed Water Wetwell Overflow									
	Underground	>4	PVC	See spec	15230	See spec	30 psig/ HH	None	None	Gravity sewer pipe or AWWA C900/905 is acceptable

PIPING SCHEDULE										
Process Abbrev.	**Service**	**Nominal Diameter (inches)**	**Material**	**Pressure Class Special Thickness Class Schedule Wall Thickness**	**Pipe Spec. Section**	**Joints/ Fittings**	**Test Pressure/ Method**	**Lining**	**Coating**	**Comments**
PLW	Plant Water Line									
	Underground	1 – 4	PVC	SCH 80	15230	SW	100 psig/ HH	None	None	
	Underground	4 – 8	DIP	CL 53	15211	MJ	100 psig/ HH	CM	PEE	
	Aboveground	1/2 - 1	COP	Type K	15283	SOLD	100 psig/HH	None	None	Aluminum jacketed insulation
	Aboveground	1 – 4	STL	SCH 40	15278	SCRD	100 psig/ HH	CM	HPC	Aluminum jacketed insulation
	Aboveground	All	DIP	CL 53	15211	FL	30 psig/ HH	CM	HPC	
RW	Reclaimed Water									
	Underground	>4	PVC	See spec	15230	See spec	30 psig/ HH	None	None	Gravity sewer pipe or AWWA C900/905 is acceptable
	Underground	1-3	PVC	SCH 80	15230	SW	100 psig/HH	None	None	
	Aboveground	0.5-3	GSP	SCH 40	15278	SCRD	100 psig/HH	None	Paint	
	Aboveground	>4	DIP	CL 53	15211	FL	30 psig/ HH	CM	HPC	
SFW	Softened Water									
	Aboveground	1-3	PVC	SCH 80	15230	SW	100 psig/HH	None	None	
SH	Sodium Hypochlorite									
	Underground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	None	
	Aboveground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	HSEP	
SMP	Sample (Chlorine)									
	Underground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	None	

PIPING SCHEDULE

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
	Aboveground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	HSEP	
V	Vent									
	Aboveground	All	CPVC	Sch 80	15259	SW	100 psig/HH	None	HSEP	

Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 15956.

AM	Air method
GR	Gravity method
HH	High head method
LH	Low head method
SC	Special case

2. Abbreviations to designate piping include the following:

B&SP	Bell and spigot
CI	Cast iron
CISP	Cast iron soil pipe
CL	Class, followed by the designation
CM	Cement mortar
COMP	Compression
COP	Copper
CTP	Coal tar pitch
DIP	Ductile iron piping
EPP	Epoxy polyurethane coating
FL	Flange
GA	Gauge, preceded by the designationGEGrooved end joint
GL	Glass lined
GSP	Galvanized steel pipe
HPC	High performance coating (per Specification 09960)
HSEP	High Solids Epoxy and Polyurethane
MJ	Mechanical joint
NPS	Nominal pipe size, followed by the number in inches
psi	pounds per square inch
psig	pounds per square inch gauge
PE	Polyethylene
PEE	Polyethylene encasement
PO	Push-on
PTW	Polyethylene tape wrap
PVC	Polyvinyl Chloride
SCH	Schedule, followed by the designation
SCRD	Screwed-On
SOLD	Soldered
STL	Steel
SST	Stainless steel
SW	Solvent welded
VCP	Vitrified clay piping
WLD	Weld

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 05120 - Structural Steel.
      d. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   3. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

1.03 SUBMITTALS

A. Shop drawings: Include schedule, indicating where supports will be installed, and drawings of pipe support system components.

B. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756.

C. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05120.
      b. Hot dip after fabrication of support in accordance with ASTM A 123.
      c. Repair galvanized surface as specified in Section 05120.
   2. Stainless steel.
      a. Fabricate as specified in Section 05120.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
      c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A 380 or A 967.
         1) Passivation treatments using citric acid are not allowed.
      d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 316L Stainless Steel.

E. Stainless steel piping system:
   1. Type 316L Stainless Steel.

F. Chemical containment areas and chemical piping:
   1. Type 316 Stainless Steel or Type 316L Stainless Steel.

G. Fasteners:
   1. As specified in Section 05120.

2.02 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For stainless steel piping:
      a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
   2. For all other piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 101.
         2) FM Stainless Fasteners.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.
         3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1C.I.
         2) Bergen-Power, Figure 100SS.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 97.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc, Figure B3100 or B3102.
         2) FM Stainless Fasteners, Figure 60.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1A.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 300.

2) Bergen-Power, Figure 100EL.
3) Cooper B-Line Systems, Inc. Figure B3108.

H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 324.
2) Cooper B-Line Systems, Inc., Figure B3110.
3) FM Fasteners, Figure 81.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 181.
2) Cooper B-Line Systems, Inc., Figure B3110.

I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) FM Stainless Fasteners, Figure 71.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 171.
2) Cooper B-Line Systems, Inc., Figure B3114.

J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 30M.
2) Cooper B-Line Systems, Inc., Figure B3066.
3) FM Stainless Fasteners, Figure 98.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 195.
2) Cooper B-Line Systems, Inc., Figure B3066.

K. Standard U-bolt: MSS SP-58, Type 24:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 110.
2) Cooper B-Line Systems, Inc., Figure B3188.
3) FM Stainless Fasteners, Figure 37.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 137.
2) Bergen-Power, Figure 283.
3) Cooper B-Line Systems, Inc., Figure B3188.

L. Riser clamps: MSS SP-58, Type 8:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure B3373.
2) FM Stainless Fasteners, Figure 61.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 261.
2) Bergen-Power, Figure 126.
3) Cooper B-Line Systems, Inc., Figure B3373.

M. Pipe clamps: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 4.
         2) Cooper B-Line Systems, Inc., Figure 3140.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 212.
         2) Bergen-Power, Figure 175.
         3) Cooper B-Line Systems, Inc., Figure B3140.

N. Adjustable offset pipe clamp:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 4.
         2) Cooper B-Line Systems, Inc., Figure B3149.
         3) FM Stainless Fasteners, Figure 63.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 100.
         2) Cooper B-Line Systems, Inc., Figure B3149.

O. Offset pipe clamp:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 8.
         2) Cooper B-Line Systems, Inc., Figure 3148.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 103.
         2) Cooper B-Line Systems, Inc., Figure B3148.

P. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 318.
         2) FM Stainless Fasteners, Figure 59.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 259.
         2) Bergen-Power, Figure 125.
         3) Cooper B-Line Systems, Inc., Figure B3090.
      c. Threaded pipe stand support stanchion. Match pipe support material.
         1) Anvil International, Figure 63T.
         2) Bergen-Power, Figure 138.
         3) Cooper B-Line Systems Inc., Figure B3088ST.

Q. Spring hangers:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 920.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure B-268, Type G.
         2) Bergen-Power, Figure 920.

R. One hole pipe clamps:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Not used.
      b. For all other piping:
         1) Anvil International, Figure 126.
         2) Carpenter & Paterson, Figure 237S.

S. Welded beam attachment: MSS SP-58, Type 22:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 304.
         2) Cooper B-Line Systems, Inc., Figure 3083.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 66.
         2) Bergen-Power, Figure 113A or 113B.
         3) Cooper B-Line Systems, Inc., Figure B3083.

T. Heavy pipe clamp: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 4H.
      b. For all other piping, unless called out otherwise on the Drawings:
         1) Anvil International, Figure 216.
         2) Bergen-Power, Figure 298.

U. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 426.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 257, Type 3.
         2) Cooper B-Line Systems, Inc., Figure B3893.

V. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers or adjustable clevis hangers, for 4 inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
   1. Any change in direction.
   2. Both sides of flexible pipe connections.
   3. Base of risers.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410.

T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install insulation shield in accordance with MSS SP-58, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the Drawings.

W. Install riser clamps at floor penetrations and where indicated on the Drawings.

X. Coat support system components as specified in Section 09960.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. Manufacturer services for each type of pipe support:
   1. Provide Manufacturer’s Certificate of Source Testing.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.

END OF SECTION

SECTION 15062

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
   2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SYSTEM DESCRIPTION

A. Design responsibility:
   1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Minimum gauge thickness: 12-gauge.
   3. Allowable stress of channels:
      a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.

b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.

4. Maximum deflection: 1/240 of span.
5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
6. Future loads:
   a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
   b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
   c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
7. Seismic design criteria: As specified in Section 01612 as specified for mechanical equipment.
8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
   1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Shop drawings: Include layout of support system including pipe loads, selected channel size, fittings, and appurtenances.

C. Structural design calculations.

1.05 QUALITY ASSURANCE

A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
   1. AISC Manual of Steel Construction.
   2. AISI Cold-Formed Steel Design Manual.

B. Product standards:
   1. Pipe support components: In accordance with MSS SP-69.
   2. Pipe support materials: In accordance with MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P1000 or P1001; P5500 or P5501.

b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
c. Cooper B-Line, Channel Type B22 or B22A; B12 or B12A.

2.02 ACCESSORIES

A. Preformed channel concrete inserts: Minimum 12 inches long.
1. Manufacturers: One of the following or equal:
a. Unistrut, Series P-3200.
b. Allied Support Systems, Figure 282.
c. Cooper B-Line, Series B32I.

B. 90-degree angle fittings:
1. Manufacturers: One of the following or equal:
a. Unistrut, P1026.
b. Allied Support Systems, Power Strut, P603.

C. Pipe straps:
1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
a. Manufacturers: One of the following or equal:
1) Unistrut, Series P1109 through P1126.
2) Allied Support Systems, PS1100.
3) Cooper B-Line, Series B2000.
2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings use 1-piece 1 inch wide by 1/8 inch thick steel strap, hot-dip galvanized after fabrication.
3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above, but use Type 316 stainless steel materials.

D. Touch-up paint galvanized surfaces:
1. Manufacturers: One of the following or equal:
a. Galvinox, Galvo-Weld.

E. Touch-up paint for painted surfaces: Same formulation as factory paint.

2.03 FABRICATION

A. Hot-dip galvanize support system components after fabrication to required length and shape.

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.

C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.

D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.

E. Touchup cut or damaged galvanized surfaces.

F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.

G. Install support as near as possible to concentrated loads.

H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.

I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 15075

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Mechanical Identification including the following:
   1. Pipe identification by color and legend.
   2. Special items.
   3. Underground warning tape.
   4. Identification of equipment and components of systems with paint, brands, tags, and signboards.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01770 - Closeout Procedures.
      b. Section 09960 - Coatings.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit as specified in General Conditions Item No. 25.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2 PRODUCTS

2.01 EQUIPMENT NAMEPLATES

A. Material and fabrication:
   1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.

B. Fasteners:
   1. Number 4 or larger oval head stainless steel screws or drive pins.

C. Text:
   1. Manufacturer's name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

2.02 PIPE IDENTIFICATION

A. Manufacturers:
   1. One of the following or equal:
      a. Seton, Opti Code Pipe Markers.
      b. Lab Safety Supply.
      c. Marking Services, Inc.

B. Materials:
   1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; meet ASME A13.1 requirements.
      a. Lettering:

Nominal Pipe Diameter	Lettering Size
Less than 1.5	1/2 inch
1.5 inches to 2 inches	3/4 inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

      b. Marker colors:

Service	Lettering	Background
Flammables, chemicals, toxics	Black	Yellow
Water, nontoxic solutions or low hazard liquids	White	Green
Nonflammable or nontoxic gases	White	Blue
Fire quenching fluids (foam, fire water, CO_2 Halon)	White	Red

   2. Coating: As specified in Section 09960.

3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4 inch high identifying lettering.
4. Pipe identification tag chains: Aluminum or stainless steel.
5. Snap-on markers: Markers with 3/4 inch high letters for 3/4 to 4 inch pipe or covering, or 5 inch high letters for 5 inch or larger pipe or cover, as manufactured by one of following:
   a. Brady Bradysnap-On B-915.
   b. Seton Setmark.

2.03 SPECIAL ITEMS

A. In addition, special coating of following items will be required:

Item	Color
Valve handwheels and levers	Red
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

2.04 UNDERGROUND WARNING TAPE

A. Manufacturer:
   1. The following or equal:
      a. Seton Name Plate Company, Branford, CT.

B. Material:
   1. Metallic detection tape; minimum 4 mil thick by 6 inches wide polyethylene film with wording, “Caution” with name of service followed by words, “Line Buried Below” repeated continuously along tape length, with alternate metallic and color strips. Colors as follows:
      a. Water: Blue.
      b. Telephone: Orange.
      c. Sewer: Green.
      d. Gas and other services: Yellow.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 PIPING IDENTIFICATION

A. Where scheduled, identify exposed piping, valves, and accessories, in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.

B. Color code:
   1. Paint all piping with colors as selected by Owner. Provide color samples for Owner approval prior to any painting.

C. Where scheduled, provide lettering and flow direction arrows:
   1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4-inch high letters on 3/4- through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
   2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.

D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.

E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.

F. Metal tags:
   1. Where outside diameter of pipe or pipe covering is 5/8 inch or smaller, provide metal pipe identification tags instead of lettering.
   2. Fasten pipe identification tags to pipe with chain.
   3. Where tags are used, color code pipe as scheduled.

G. Underground warning tape:
   1. Place warning tape in pipe trench, 12 inches above the pipe.

3.04 APPLICATION

A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.

B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15 foot spacing on piping runs.

C. Provide piping marker letters and colors as scheduled.

D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

3.05 PIPING COLOR CODE AND MARKER SCHEDULE

Service	Flow Stream Identifiers	Color	Lettering/Flow Direction Arrows
Reclaimed water	PLW, RW	Purple	None
Air	ALP	Light Tan	None
Activated Sludge	WAS, RAS, ML, DEW	Tan	None
Sludge	DS	Dark Brown	None
Drain	D, SUP, RET	Dark Grey	None
Scum	SSM	Light Brown	None
Other	Other	Request from Owner	None

END OF SECTION

SECTION 15076

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification by color and legend.
   2. Underground warning tape.
   3. Tracer wire.
   4. Witness markers.
   5. Valve identification.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01600 - Product Requirements.
      c. Section 01770 - Closeout Procedures.
      d. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2 PRODUCTS

2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

A. Manufacturers:
   1. One of the following or equal:
      a. Seton, Opti Code Pipe Markers.
      b. Lab Safety Supply.
      c. Marking Services, Inc.

B. Materials:
   1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
      a. Lettering:

Nominal Pipe Diameter	Lettering Size
Less than 1.5	1/2 inch
1.5 inches to 2 inches	3/4 inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

      b. Marker colors:

Service	Lettering	Background
Flammables, chemicals, toxics	Black	Yellow
Water, nontoxic solutions or low hazard liquids	White	Green
Nonflammable or nontoxic gases	White	Blue
Fire quenching fluids (foam, fire water, CO_2 Halon)	White	Red

   2. Coating: As specified in Section 09960.
   3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4 inch high identifying lettering.
   4. Pipe identification tag chains: Aluminum or stainless steel.
   5. Snap-on markers: Markers with 3/4 inch high letters for 3/4 to 4 inch pipe or covering, or 5 inch high letters for 5 inch or larger pipe or cover, as manufactured by one of following:
      a. Brady Bradysnap-On B-915.
      b. Seton Setmark.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton Name Plate Company, Branford, CT.
      b. T. Christy Enterprises, Inc.
      c. .
   2. Material:

a. Polyethylene tape for prolonged underground use.
b. Minimum tape thickness: 4 mils.
c. Overall tape width: 6 inches.
d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved APWA colors.
    1) Water: Blue.
    2) Sewer: Green.
    3) Telephone: Orange.
    4) Gas and other services: Yellow.

B. Tracer wire:
1. Manufacturers: One of the following or equal:
    a. Kris-Tech Wire.
    b. Corrpro.
    c. .
2. Materials: One of the following or equal:
    a. Solid copper conductor with 30 mil HMWPE.
    b. 10 gauge or thicker wire.
    c. Match insulation color to the color of the pipe being installed.

C. Witness markers:
1. Manufacturers: One of the following or equal:
    a. Carsonite Composites, Utility Marker.
    b. Hampton Technical Associates, Inc.
    c. .
2. Materials:
    a. Glass fiber and resin reinforced thermosetting composite material.
    b. UV resistant.
3. Constructed as a single piece.
4. Pointed at the bottom end...
5. Information to be included on the marker:
    a. “Caution” (type of service) “Pipeline”.
    b. Phone number for[Underground Service Alert.
    c. Phone number for Owner in case of emergency.
    d. Station number.
    e. Offset:
        1) Only provide offset if marker is not directly over the pipe.
    f. Name of appurtenance or fitting (e.g. 45, BO, ARV etc.)

2.03 VALVE IDENTIFICATION

A. The Contractor shall furnish and install tags for all valves and gates required for the Work.
1. Tags shall be 2-in diameter round, stainless steel for buried applications.
2. Tags shall be furnished with a non-corrosive metal wire suitable for attaching the tag to the operator base.
3. Tags shall be stamped in 1/4-inch high letter
    a. Tags shall not be attached in such a way as to inhibit the operation of the valve or gate.
4. Buried valve tags shall be secured to concrete s with the specified valve or gate number.

5. Submit 2 samples of the type of tag proposed and the manufacturer's standard color chart and letter styles to the Engineer for review.
6. Manufacturer: The following or equal:
   a. Seton Name Plate Company, Branford, CT.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed piping, valves, and accessories, and piping, valves, and accessories in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.

B. Color code:
   1. Paint all piping with colors as selected by Owner.

C. Lettering and flow direction arrows:
   1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4 inch high letters on 3/4 through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
   2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.

D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.

E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.

F. Metal tags:
   1. Where outside diameter of pipe or pipe covering is 5/8 inch or smaller, provide metal pipe identification tags instead of lettering.
   2. Fasten pipe identification tags to pipe with chain.
   3. Where tags are used, color code pipe as scheduled.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:

1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
      a. Twisting the wires together is not acceptable.

C. Witness markers:
   1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
   2. Place markers at appurtenances located in unpaved areas.
   3. Embed markers at least 18 inches into the soil.

3.05 APPLICATION

A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.

B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15 foot spacing on piping runs.

C. Provide piping marker letters and colors as scheduled.

D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

END OF SECTION

SECTION 15082

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Insulation for piping and related systems.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02318 - Trenching.
      b. Section 09960 - Coatings.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15075 - Equipment Identification.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   2. C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   3. C 518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   4. C 533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   5. C 547 - Standard Specification for Mineral Fiber Pipe Insulation.
   6. C 552 - Standard Specification for Cellular Glass Thermal Insulation.
   7. C 795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
   8. C 929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
   9. C 1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   10. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

11. D 2310 - Standard Classification of Machine-Made "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
12. E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
13. E 96 - Standard Test Methods for Water Vapor Transmission of Materials.

1.03 DEFINITIONS

A. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.

B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.

C. Exterior: Piping that is installed under canopies, outside a building or within a pipe trench or tunnel.

D. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E 84. No units apply to value.

E. Interior: Piping that is installed inside a building.

F. K factor: Thermal conductivity determined in accordance with ASTM C 177 or C 518 and expressed in units of BTU-inch/hour-square feet-degrees Fahrenheit.

G. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.

H. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E 96 and expressed in units of perm-inch.

1.04 SUBMITTALS

A. Product data:
   1. Insulation properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E 84 and corrosivity to stainless steel piping in accordance with ASTM C 795.
   2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E 96, flame spread, and smoke developed in accordance with ASTM E 84, closure type or devices, and accessories.
   3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.

B. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.

C. Laboratory report: Provide certified laboratory report stating that insulation is not manufactured using chlorinated polymers and does not contain chlorides, bromides, sulfates, or fire-rated materials.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store insulation materials and accessories under cover and protected from moisture.

B. Handle and store insulation for use on stainless steel in accordance with ASTM C 929.

1.06 SEQUENCING AND SCHEDULING

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

PART 2 PRODUCTS

2.01 PIPE INSULATION, GENERAL REQUIREMENTS

A. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

Required Insulation Thicknesses (inches)					
Service Temperature Range as Designated in Insulation Schedule at End of this Section	**Nominal Pipe Diameters**				
	1 inch & less	**1.25 to 2 inch**	**2.5 to 4 inch**	**5 to 10 inch**	**Over 10 inch**
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

2.02 PIPE INSULATION

A. Insulation types: Provide in accordance with the insulation types listed and scheduled.

B. Insulation, Type 1:
   1. Insulation material: Closed cell elastomeric insulation.
   2. Manufacturers: One of the following or equal:
      a. Armstrong World Industries, AP Armaflex.
      b. Apache Products Company, ISO-25.
   3. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
   4. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet degrees Fahrenheit.
   5. Fire ratings:
      a. Flame spread: 25 or less.
      b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
   6. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.

C. Insulation, Type 2:
   1. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
      a. In accordance with ASTM C 547, Class 1.
      b. Provide with factory installed vapor barrier.
         1) Material: White kraft paper bound to aluminum foil in accordance with ASTM C 1136, Type I.
         2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
         3) Circumferential butt seals: 4-inch wide tape or similar properties or 4-inch wide overlap with adhesive seal.
         4) Vapor barrier permeability: 0.02 perms or lower.
         5) Vapor barrier flame spread rating: 25 or less.
   2. Minimum temperature range: Minus 0 degrees Fahrenheit to plus 850 degrees Fahrenheit.
   3. K factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-inch/hour-square feet degrees Fahrenheit.
   4. Average insulation density: 3.3 pounds per cubic foot.
   5. Maximum moisture absorption, volume percent: 0.2.
   6. Manufacturers: One of the following or equal:
      a. Owens-Corning Fiberglas Corp.
      b. Johns Manville
      c. Knauf Fiber Glass.

D. Insulation, Type 3:
   1. Insulation material: Rigid cellular glass in accordance with ASTM C 552, Type II.
   2. Temperature range: Minus 450 degrees Fahrenheit to plus 900 degrees Fahrenheit.
   3. K factor at 75 degrees Fahrenheit: Not more than 0.32 BTU-inch/hour-square feet degrees Fahrenheit.

4. Minimum average density: 7.5 pounds per cubic foot.
5. Maximum moisture absorption, volume percent: 0.2.
6. Minimum compressive strength: 87 pounds per square inch.
7. Moisture permeability: 0.00 perm-inch.
8. Manufacturers: One of the following or equal:
    a. Pittsburgh Corning Corporation, Foamglas.
    b. Cell-U-Foam Corporation, Ultra-CUF.

2.03 INSULATION JACKETS

A. Jacket, Type 1:
1. Material: 28 ounces per square yard polyvinyl chloride on polyester fabric; total thickness 0.028 inches minimum.
2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: As selected by the Engineer from manufacturer's standard colors.
4. Overlap: 1-inch minimum at joints and fittings.
5. Joint seal: Self-sealing lap tape.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Accessible Products, Techlite Insulation, 379 SSL Series.

B. Jacket, Type 2:
1. Material: Ultraviolet resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: White.
4. Overlap: 1-inch minimum at joints and fittings.
5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Johns Manville, Zeston 2000 PVC.
    b. Proto Corp., LoSMOKE PVC.
    c. Speedline Smoke Safe PVC Jacketing System.
    d. Knauf Covering System.

C. Jacket, Type 3:
1. Material: Aluminum, Alloy 5005; 0.016-inch (26 gauge) minimum thickness.
2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
3. Bands: 0.5 inch wide, 0.0508-inch (16 gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
4. Joint seal: Apply waterproof adhesive at joints and overlaps.
5. Fittings: Custom fit of same materials.
6. Manufacturers: One of the following or equal:
    a. Childers Products.
    b. Premetco International.

2.04 VAPOR BARRIERS

A. Vapor barrier, Type 1:
   1. Material: White kraft paper bound to aluminum foil in accordance with ASTM C 1136, Type 1.
   2. Permeability: 0.02 perms or lower.
   3. Maximum flame spread rating: 25.
   4. Edge seal: Pressure sensitive tape lap seal.
   5. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.

B. Vapor barrier, Type 2:
   1. Material: Mastic.
   2. Manufacturers: One of the following or equal:
      a. Benjamin Foster, No. 30-76.
      b. Insul-Coustic, No. I.C.-580.
      c. Foster Products, 36-10/46-10 Weatherite.
      d. Childers Products CP10/11 Vi-Acryl.

2.05 RELATED MATERIALS

A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard duty adhesives are not permitted.

2.06 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.

B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3-inch in nominal size and larger. Insulate equipment and piping appurtenances less than 3-inch with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers: One of the following, or equal:
   1. Pittsburgh Corning, Temp-Mat.
   2. Accessible Products, Thermazip 2000 Jacket.
   3. Thermal Energy Products, Inc., Energy Wrap.

D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
   1. Use: For service temperatures up to 800 degrees Fahrenheit.
   2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees Fahrenheit.
   3. Cover: 17-ounce fabric with both sides covered with silicone impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire; or
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit:
   1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit.
   2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
   3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire; or
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Before installing insulation, verify satisfactory completion of pressure tests of piping systems and functional tests of heat tracing equipment.

B. Examine piping surfaces and verify that surfaces are dry and free of loose scale, rust, dirt, oil, or water before applying insulation. When specified, paint or coat pipe surfaces as specified in Section 09960 before installing insulation.

C. Examine insulation materials and accessories before installation. Do not install insulation and jackets that have been damaged or insulation that has become wet due to exposure to water.

3.02 INSTALLATION

A. Install insulation and jacket materials in accordance with manufacturer's written instructions.

B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.

E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

G. Fittings:
   1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
   2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
   3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

H. Valves:
   1. Insulate valves 3-inch in nominal size and larger with removable insulating blankets.
   2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.

I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.

K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

M. Apply premolded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

N. Thermally isolate all insulation closure locations (end caps, transitions, etc.) Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.

O. Apply piping identification on jackets as specified in Section 15075.

3.03 INSULATION SCHEDULE

Service Designation (1)	Location(2)	Insulation Type(3)	Jacket Type(3)	Service Temp. °F(4)	Vapor Barrier
Hot Water (1W)	Interior or Exterior	1 or 2	Type 2 on Exterior installations, none req'd on Interior installations	100-200	Install on Type 2 insulation
Potable Water	Exterior	1	2	Below 40	Required
Low Pressure Air (ALP)(6)	Interior	2	1	Aeration air pipe	Required
	Exterior	3	2		

Service Designation [1]	Location[2]	Insulation Type[3]	Jacket Type[3]	Service Temp. °F[4]	Vapor Barrier
Heat Traced Pipes[7]	Exterior	1 or 2	2	Use thickness established in Table in paragraph 2.01	Install on Type 2 insulation

Notes:

1. Refer to Piping Schedule in Section 15052 for service designations.
2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
3. Contractor may select from options listed.
4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table in Paragraph 2.01A.
5. Service temperature based on engine rating. Use Type I calcium silicate for exhaust temperatures up to 1,000 degrees Fahrenheit, use Type II calcium silicate for exhaust temperatures above 1,000 degrees Fahrenheit.
6. Install insulation on all Low Pressure Air piping located where it can be touched. .
7. Insulate all piping systems that are specified to be heat traced.

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 01782 - Operation and Maintenance Data.
      d. Section 09960 - High-Performance Coatings.
      e. Section 15211 - Ductile Iron Pipe: AWWA C151.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A 167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   3. A 536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP 7 - Brush-Off Blast Cleaning.
   2. SP 10 - Near-White Blast Cleaning.

1.03 DESIGN REQUIREMENTS

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.

2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Valves 3 inch nominal size and larger: Flanged ends.
   2. Valves less than 3 inch nominal size: Screwed ends.
   3. Plastic valves in plastic piping:
      a. Up to 2.5 inches: Provide solvent or heat welded unions.
      b. 3 inches and above: Provide solvent or heat welded flanges.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Power valve actuators:
         1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
         2) Complete wiring diagrams and control system schematics.
      d. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      f. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
      h. Factory test data.

C. Provide vendor operation and maintenance manual as specified in Section 01782.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inch in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756.

E. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.06 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless steel: In accordance with ASTM A 167, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts:
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Valve bodies: Cast iron in accordance with ASTM A 126, Class 30 minimum or ductile iron in accordance with ASTM A 536, Grade 65-45-12 minimum unless specified otherwise.

2.02 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: One of the following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012 inches except that:
         1) Lining thickness in grooves for gaskets: 0.005 inches.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.

2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
   a. Product equivalent to high solids epoxy specified in Section 09960.
      1) Certified in accordance with NSF 61 for drinking water use.
      2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy coating specified in Section 09960.
   b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
   c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
      1) Repair holidays and other irregularities and retest coating.
      2) Repeat procedure until holidays and other irregularities are corrected.

2.03 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
   1. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15211.
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 STEAM VALVES

A. Valves in steam or steam condensate piping: Ductile iron body in accordance with ASTM A 536, Grade 65-45-12 minimum or cast steel or forged steel.

2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
   1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.

2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
   1. Tyler Pipe Industries, Inc.
   2. Neenah Foundry Company.

2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inch square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Install valves with their stems in vertical position above the pipe, except as follows:
   1. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
   2. Install buried plug valves with geared operators with their stems in a horizontal position.

D. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

F. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon tape on external (male) threads to prevent forcing compound into valve seat area.

G. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

H. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services from each manufacturer for all valves supplied,
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators.

1. Source testing.
2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

SECTION 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Metal body ball valves and plastic body ball valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 15052 - Common Work Results for General Piping.
      c. Section 15110 - Common Work Results for Process Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SYSTEM DESCRIPTION

A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

1.04 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Section 01330 and Section 15110:
   1. Product data.
   2. Certificates:
      a. Metal body ball valves: 6 inches and larger only. Submit affidavit of compliance in accordance with AWWA C507.
   3. Operation and maintenance data.

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, 6 INCH SIZE AND LARGER

A. Manufacturers: One of the following or equal:
   1. APCO Willamette.
   2. GA Industries.
   3. Crane Co., Inc.
   4. Henry Pratt.

B. General:
   1. Type: Non-lubricated, resilient seated and capable of sealing in either flow direction.
   2. In accordance with AWWA C507.
   3. Stem packing: Manually adjustable while valve is under pressure.
   4. ASME B16.1, Class 125 flanged ends.

C. Materials:
   1. Body: ASTM A 48 cast iron and integrally cast bronze bushed trunnions.
   2. Ball: Type 304 or Type 316 stainless steel.
   3. Seats: PTFE.
   4. Stem seals: PTFE or Viton.

D. Valve actuator:
   1. Manually operated valves: Self-locking worm gear type actuator with position indicator. Permanently lubricate gearing. Provide adjustable screws to stop travel at both open and closed positions.

2.02 METAL BODY BALL VALVES, LESS THAN 6 INCH SIZE

A. Manufacturers: One of the following, or equal:
   1. Apollo Valves as manufactured by Conbraco Industries, Inc.
   2. Metso Automation/Jamesbury.
   3. NIBCO, Inc.
   4. Flow-Tek, Inc.

B. General:
   1. Type: Non-lubricated, full port and capable of sealing in either direction.
   2. End connections:
      a. Threaded or solder ends for sizes 3 inches and smaller.
      b. Class 150 flanged for sizes larger than 3 inches.
         1) Flanges: In accordance with ASME B16.1 standards.

3. Stem packing: Manually adjustable while valve is under pressure.
4. Shafts:
    a. Rigidly connected to the ball by a positive means.
        1) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
5. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
6. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.

C. Materials:
1. Valves in copper lines: Bronze body.
2. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
3. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 15052.
4. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
5. Seats: PTFE.
6. Stem seals: PTFE or Viton.
7. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
8. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

2.03 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
1. Asahi America.
2. Chemtrol Division, NIBCO, Inc.
3. Hayward.
4. Spears.

B. General:
1. Type: Non-lubricated and capable of sealing in either flow direction.
2. End connections: True union; solvent or heat welded to piping.
3. Operator handle: Lever.

C. Materials:
1. Body: Polyvinyl chloride (PVC/CPVC).
2. Ball: Polyvinyl chloride (PVC/CPVC).
3. Seats: PTFE (Teflon).
4. O-rings: FKM (Viton).

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

B. Special techniques:
   1. PVC ball valves for hypochlorite service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating "One side of ball drilled for hypochlorite service."

END OF SECTION

SECTION 15112

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Butterfly valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 09960 - Coatings.
      c. Section 13446 - Manual Actuators.
      d. Section 13447 - Electric Motorized Actuators.
      e. Section 15110 - Common Work Results for Valves.
      f. Section 15211 - Ductile Iron Pipe, AWWA C151.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125 and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C504 - Rubber-Seated Butterfly Valves.
   3. C540 - Standard for Power-Actuating Devices for Valves and Sluice Gates.
   4. C550 - Protective Interior Coatings for Valves & Hydrants.
   5. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for Higher-Temperature Service.
   3. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   5. A 395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

6. A 479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
7. A 515 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate - and Higher-Temperature Service.
8. A 516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower-Temperature Service.
9. A 536 - Standard Specification for Ductile Iron Castings.
10. A 564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
11. A 582 - Standard Specification for Free-Machining Stainless Steel Bars
12. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
13. D 429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrate.

D. Compressed Gas Association (CGA):
1. Standard G-4.1 - Cleaning Equipment for Oxygen Service.

E. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
1. General purpose AWWA butterfly valves:
a. Design standard: Provide valves designed and manufactured in accordance with AWWA C504.
b. Class:
1) Provide butterfly valves in accordance with AWWA Class 150B, unless otherwise specified.
2) Provide butterfly valves in accordance with AWWA Class 250B in piping systems with test pressure greater than 150 pounds per square inch and less than 250 pounds per square inch.
2. High pressure butterfly valves:
a. Piping systems designed for operating pressures greater than 250 pounds per square inch and less than 450 pounds per square inch: Provide ASME B16.5, Class 300 high pressure valves.
3. Industrial class butterfly valves:
a. Industrial class butterfly valves capable of 150 pounds per square inch leak tight shut off.
4. Stainless steel butterfly valves:
a. Stainless steel butterfly valves capable of a minimum of 100 pounds per square inch leak tight shut off and with special cleaning, packaging, and handling.

B. Usage:
1. Provide and install butterfly valve types as outlined in the Butterfly Valve Application Schedule at the end of this Section.

C. Design requirements for all butterfly valves with power actuating devices:
   1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
      a. Maximum water velocity: 16 feet per second with valve fully open.
      b. Maximum pressure differential across the closed valve equal to the pressure class designation.
      c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with valve manufacturer's published recommendations.
   2. Valve disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions:
      a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.
   3. Unacceptable thrust bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.

D. Performance requirements:
   1. Tight shutoff at the pressure rating of the valve with pressure applied in either direction.
   2. Suitable for the following service conditions:
      a. Throttling.
      b. Frequent operation.
      c. Operation after long periods of inactivity.
      d. Installation in any position and flow in either direction.

1.04 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Section 01330 and Section 15110:
   1. Product data:
      a. For general purpose AWWA butterfly valves, include description of the method of attachment of the disc edge to the valve disc.
   2. Certificates:
      a. General purpose AWWA butterfly valves:
         1) Proof-of-design tests: Certified statement that proof-of-design tests were performed and all requirements were successfully met.
         2) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C504.
      b. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions in accordance with AWWA C550.
      c. Certification, for all valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF Standard 61.
   3. Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GENERAL PURPOSE AWWA BUTTERFLY VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik/Sartell Model BAW.
   2. Henry Pratt Company.

B. Valve body:
   1. Material: Cast iron, ASTM A 126, Grade B, or ductile iron, ASTM A 536, Grade 65-45-12.
   2. Body design:
      a. Flanged body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Flanges: In accordance with ASME B16.1 Class 125 flanges for Class 150B valves, in accordance with ASME B16.1 Class 250 flanges for Class 250B valves.
      b. Mechanical joint body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Mechanical joint design: In accordance with AWWA C110.
         3) When mechanical joint body valves are used, incorporate valve into thrust restraint analysis as specified in Section 15211. Utilize test pressure on one side of valve and zero pressure on the opposite side of the valve. Restrain pipe joints on both sides of valve as determined by thrust analysis calculations.
      c. Wafer body valves:
         1) Usage: Comply with installation limitations specified in the Butterfly Valve Application Schedule.
         2) Body design: Lugged design with boltholes drilled and tapped to accept flange bolts. Wafer body valves that are installed by mating between flanges are not acceptable.
         3) Locate lugged style valves in piping systems such that when the valve is operated, the opening of the valve disc will not interfere with, nor be impaired by, adjacent piping, fittings, valves, equipment, or other installations.
      d. Grooved end body valves:
         1) Usage: Butterfly valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints. Comply with additional limitations specified in the Butterfly Valve Application Schedule.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Disc:
   1. Material: Cast iron or ductile iron with Type 316 stainless steel edge that matches seat in valve body.
   2. Secure valve disc to shaft by means of smooth-sided, taper or dowel pins, Type 316 stainless steel, or Monel.
   3. Extend pins through shaft and mechanically secure in place.

D. Shaft and bearings:
   1. Shaft design:
      a. Valves 20-inch and less: 1 piece, through disc design.
      b. Valves greater than 20-inch size: 2 piece, stub shaft design.
   2. Shaft seal: Vee type, chevron design.
   3. Shaft material for Class 150B valves: Type 316 stainless steel, ASTM A 276.
   4. Shaft material for Class 250B valves: Type 17-4 pH stainless steel, ASTM A 564.
   5. Shaft bearings: Self-lubricating sleeve type:
      a. Valves 20-inch and less: Nylatron.
      b. Valves greater than 20-inch size: Teflon with stainless steel or fiberglass backing.

E. Seats:
   1. Seat materials:
      a. In low-pressure air applications: EPDM.
      b. In all other applications: EPDM.
   2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
   3. For valves 24 inches in nominal size and larger, retain seats mechanically or by adhesive:
      a. Mechanical retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws.
         1) Clamping ring, ring locks, and adjusting locking screws: Type 316 stainless steel.
         2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
      b. Adhesive retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.
      c. Do not provide valves with seats retained by snap rings or spring-loaded retainer rings.
   4. Resilient seat: Withstand 75 pound per inch pull when tested in accordance with ASTM D 429, Method B.

F. Valve packing:
   1. Valves 4 inch to 48 inch nominal size: Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.
   2. Valves 54 inch nominal size and larger: Adjustable V-type packing with bronze packing gland or self-adjusting V-type packing. NBR or EPDM to match seat material.

2.02 BUTTERFLY VALVE ACTUATORS

A. Motorized actuators are specified in Section 13447. Additional requirements for manual actuators are specified in Section 13446.

B. Manual actuators for aboveground valves, 4 inches in nominal size and smaller for liquid service, and 10 inches in nominal size and smaller for aeration air service.
   1. For valves operating at pressures up to and including 250 pounds per square inch, provide hand lever type with locking device so that the valve can be locked in any position with a wing nut.
      a. Locking device: Rigid, allowing no vibration or chattering of the valve.
      b. Hand lever: 12 inches long, with handgrip.
   2. For valves operating at pressures above 250 pounds per square inch, provide totally enclosed worm gear actuator mounted on the valve.

C. Manual actuators for aboveground valves in nominal sizes and in service applications other than specified above, except for valves 30 inches and larger.
   1. For valves operating at pressures up to and including 250 pounds per square inch, provide either a totally enclosed worm gear actuator or a totally enclosed traveling nut actuator mounted on the valve.
   2. For valves operating at pressures above 250 pounds per square inch, provide totally enclosed worm gear actuator mounted on the valve.

D. Manual actuators for aboveground valves 30 inches in nominal size and larger, all pressures.
   1. Provide totally enclosed worm gear actuator mounted on the valve.

E. Manual actuators for buried or submerged valves, all sizes, and pressures.
   1. Provide totally enclosed travelling nut actuator mounted on the valve.
   2. Actuators for buried or submerged valves: Hermetically sealed and grease packed.
   3. For buried valves, provide 2-inch square AWWA nut on enclosed actuator.
   4. For buried valves, provide extension stem, valve box, and valve box cover as specified in Section 15110.
   5. For submerged valves, provide extension stem as indicated on the Drawings.

F. Position indication:
   1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.

G. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
   1. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
   2. Rating: Rated for 10 amps, 120 volts alternating current.
   3. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.

2.03 COATING

A. Shop coat interior and exterior metal surfaces of valves, except as follows:
   1. Interior machined surfaces.
   2. Surfaces of gaskets and elastomeric seats and stem seals.
   3. Bearing surfaces.
   4. Stainless steel surfaces and components.

B. Coating material for potable water applications:
   1. Formulate coating material from materials in accordance with CFR 21.

C. Field applied coatings:
   1. Additional coating of the valve exterior will be required to match the epoxy or epoxy/polyurethane paint system as specified in Section 09960.
      a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
      b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

D. Surface coatings:
   1. Interior surfaces, except for valves used in low-pressure air service: High solids epoxy.
   2. Interior surfaces of valves used in low-pressure air service: High temperature coating for range of 150 to 350 degrees Fahrenheit, as specified in Section 09960.
   3. Exterior surfaces of valves, actuators, and accessories:
      a. Submerged valves: High solids epoxy.
      b. Buried valves: Coal tar epoxy.
      c. Other valves: High solids epoxy with polyurethane topcoat.
   4. Polished and machined surfaces: Apply rust-preventive compound.

E. Coating materials:
   1. High solids epoxy and coal tar epoxy:
      a. Products: As specified in Section 09960:
         1) Coating product in contact with potable water must be in accordance with AWWA C550 and NSF 61.
   2. High temperature coating: As specified in Section 09960 and in accordance with AWWA C550.
   3. Rust-preventive compound: One of the following or equal:
      a. Houghton, Rust Veto 344.
      b. Rust-Oleum, R-9.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.

B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.

3.02 BUTTERFLY VALVE APPLICATION SCHEDULE

A. Acceptable butterfly valve types and body styles are listed in the Butterfly Valve Application Schedule provided at the end of this Section. Furnish and install butterfly valves in accordance with this Schedule.

BUTTERFLY VALVE APPLICATION SCHEDULE	
Valve Type and Style	**Acceptable Applications**
General Purpose AWWA Butterfly Valves – Flanged Body Design	Aboveground or submerged in the following service applications only: - Acceptable in all service applications except oxygen and ozone service and high-pressure service. - May be used in buried applications when required by the specified piping system.
General Purpose AWWA Butterfly Valves – Mechanical Joint Body Design	Buried in the following service applications only: - Acceptable in all service applications except oxygen and ozone service and high-pressure service.
General Purpose AWWA Butterfly Valves – Lugged Body Design	Aboveground in the following service applications only: - Aeration Air Systems
General Purpose AWWA Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.
General Purpose AWWA Butterfly Valves – Grooved End Body Design	Aboveground, in sizes 20-inch and less, with piping system test pressure less than 100 psi, and in the following service applications only: - Acceptable in all service applications, except oxygen and ozone service, where piping for that service is specified in the Piping Schedule to have grooved end joints.
High Pressure Butterfly Valves – Flanged Body Design	Service applications with piping system test pressure greater than 250 psi. Acceptable in aboveground and buried installations.
High Pressure Butterfly Valves – Wafer or Lugged Wafer Body Design	Not allowed.
Industrial Class Butterfly Valves – Lugged Body Design	Aboveground in the following service applications only: - Aeration Air Systems - Natural Gas Systems - Digester Gas Systems - Chilled and Hot Water Systems
Industrial Class Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.
Stainless Steel Butterfly Valves - Lugged Body Design	Aboveground in the following service applications only: - Oxygen Systems - Ozone Systems

BUTTERFLY VALVE APPLICATION SCHEDULE	
Valve Type and Style	**Acceptable Applications**
Stainless Steel Butterfly Valves – Wafer (not lugged) Body Design	Not allowed.

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Swing and center guide check valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch (50-mm Through 600-mm) NPS.

C. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 313 - Standard Specification for Stainless Steel Spring Wire.
   3. A 536 - Standard Specification for Ductile Iron Castings.
   4. B 582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
   5. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Check valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
      a. In either horizontal or vertical position.
      b. Suitable for service working pressures up to 150 pounds per square inch gauge.

1.04 SUBMITTALS

A. Submit the following information as specified in Sections 01330 and 15110:
   1. Product data.
   2. Certificates:
      a. General purpose AWWA check valves:
         1) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C508.
   3. Operation and maintenance data.

PART 2 PRODUCTS

2.01 SWING CHECK VALVES

A. Valves 1/4 inch through 3 inch:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Company, Number 36.
      b. Lunkenheimer Company, Figure 554Y.
   2. Valve design:
      a. Threaded joints.
      b. Y-pattern body with integral seat.
      c. Hinged disc.
      d. Access to valve seat for regrinding without disassembly of piping.
   3. Materials:
      a. Body, cap, hinge, and disc: Bronze.

B. Valves 4 inch through 24 inch:
   1. Manufacturers: One of the following or equal:
      a. Kennedy, Figure 106LW.
      b. Mueller Company, Model A-2600.
      c. M&H, Model 159.
   2. Valve design:
      a. In accordance with AWWA C508.
      b. Constructed to permit top entry and removal of internal components without removing the valve.
      c. Equipped with outside lever and weight.
   3. Materials:
      a. Body: Cast iron, ASTM A 126 Class B.
      b. Disc:
         1) 4-inch valves: Bronze.
         2) 6 inches and larger valves: Bronze faced.
         3) Rubber seat Buna-N or EPDM.
      c. Hinge pins: Stainless steel.

2.02 CENTER GUIDE (SILENT) CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. APCO, Model Number 600.
   2. Crispin, Series GC.

B. Valve design:
   1. Center guided, spring-loaded plug.
   2. Replaceable seat and plug.
   3. Shaft guide bushing.
   4. Non-slam, silent shut-off.
   5. Flanged body.

C. Materials:
   1. Body: Cast iron, ASTM A 126 Grade B, or Type 316 stainless steel, ASTM A 313.
   2. Plug and seat: Bronze, ASTM B 584 C83600.
   3. Spring: Stainless steel, ASTM A 313 Type 316.
   4. Shaft and bushing: Bronze, ASTM B 584 C83600.
   5. Seat: Buna-N or EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and the manufacturer's instructions.

3.02 ADJUSTING

A. Adjust weight on swing check valves to affect proper closing action on equipment shutdown.

END OF SECTION

SECTION 15115

GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gate, globe, angle, plug disc and plain hose valves, and yard hydrants.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01756 - Commissioning and Process Start-Up.
      b. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (AMSE).

B. American Water Works Association (AWWA):
   1. C515 - Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
   2. C 550 - Protective Interior Coatings for Valves and Hydrants.

C. ASTM International (ASTM):
   1. B 98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

1.03 SUBMITTALS

A. As specified in Section 15110.

B. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves comply in accordance with all provisions of AWWA C550.

PART 2 PRODUCTS

2.01 GATE VALVES

A. Gate valves aboveground:
   1. Valves less than 3 inches in size for clean water and air service:

a. Manufacturers: One of the following or equal:
   1) Crane, Figure 431.
   2) Jenkins, Figure 47.
   3) Lunkenheimer Company, Figure 2151.
b. Design:
   1) Size and configuration: Indicated on the Drawings.
   2) Manufacturer's standard bronze, solid wedge disc, rising stem, screwed end, Class 150 pounds.

2. Valves 3 inches in size and larger:
   a. Manufacturers: One of the following or equal:
      1) M&H/Kennedy Valve Company.
      2) Mueller.
      3) American Flow Control, Series 2500.
   b. Design:
      1) Size, material, configuration: Indicated on the Drawings.
      2) Resilient wedge type in accordance with AWWA C515.
      3) Flange, iron body, and bonnet rated for 200 pound working pressure.
         a) Provide O-ring seal between valve body and bonnet.
      4) Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
      5) Bronze stem with double or triple O-ring or braided packing stem seals.
      6) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
      7) Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.

B. Gate valves underground:
   1. Manufacturers: One of the following or equal:
      a. M&H/Kennedy Valve Company.
      b. Mueller Company.
      c. American Flow Control.
   2. Design:
      a. Size, material, configuration: Indicated on the Drawings.
      b. Resilient wedge type in accordance with AWWA C515.
      c. Stem:
         1) Iron body, resilient seat, non-rising stem, double O-ring stem seal.
         2) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
      d. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
      e. Bronze stem with double or triple O-ring or braided packing stem seals.
      f. Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.
      g. Valve operator: Provide standard AWWA 2-inch operating nut, matching valve key, and valve box for operating stem.

2.02 GLOBE AND ANGLE VALVES

A. General purpose globe and angle valves:
   1. Valves 3 inches and smaller:
      a. Manufacturers: One of the following or equal:

1) Except in welded steel piping:
a) Crane, No. 1 Globe or No. 2 Angle.
b) Lunkenheimer Company Figure No. 2140 Globe or No. 2141 Angle.
2) In Welded steel piping:
a) Crane, No. 351.
b) Lunkenheimer Company, Figure No. 1123; or equal with flanged ends.

b. Design:
1) Size and configuration: Indicated on the Drawings.
2) Valve: Class 125 threaded ends, rated for 250 degrees Fahrenheit at pressure of 170 pounds per square inch.

2. Valves larger than 3 inches:
a. Manufacturers: One of the following or equal:
1) Crane, No. 351.
2) Lunkenheimer Company, Figure No. 1123.
b. Design:
1) Size and configuration: Indicated on the Drawings.

3. Plug disc globe valves: for throttling or for severe service.
a. Manufacturers: One of the following or equal:
1) Crane, No. 212P or No. 384P.
2) Lunkenheimer Company, 72-PS or 73-PS1.
b. Design:
1) Size and configuration: Indicated on the Drawings.
2) Material: Iron body stainless steel trimmed plug type seat and disc.

2.03 NEEDLE VALVES

A. Manufacturers: One of the following or equal:
1. Powell, Figure No. 180.
2. Lunkenheimer Company, Figure No. 906-BS or No. 907-BS.
3. Crane No. 88 or No. 89.

B. Design:
1. Size and configuration: Indicated on the Drawings.

2.04 HOSE VALVES AND YARD HYDRANTS

A. Hose valves:
1. Manufacturers:
a. Globe threaded valve: One of the following or equal:
1) Crane, No. 7TF.
2) Stockham, Figure No. B22T.
b. Angle threaded valve: One of the following or equal:
1) Crane, No. 17TF.
2) Stockham, Figure No. B222T.

2. Design:
a. Size and configuration: Indicated on the Drawings.
b. Valve: Globe or angle valve with threaded ends.
c. Disc: Renewable, made of Teflon or Buna-N.
d. Threaded ends rated for a pressure of 200 pounds per square inch.

B. Freezeless yard hydrant:
   1. Manufacturers: One of the following or equal:
      a. Kupferle Foundry Company.
         1) #1 Total Eclipse Yard Hydrant - 3/4 inch and 1 inch.
      b. Murdock Company:
         1) #M-75 – 3/4 inch or #M100 - 1 inch.
      c. Zurn Company:
         1) #1385 - 3/4 inch or 1 inch.
   2. Design:
      a. Self draining, non-freezing, compression type.
         1) Inlet connection size: Indicated on the Drawings.
         2) Outlet connection size: Indicated on the Drawings.
         3) Materials:
            a) Exterior casing pipe material: Indicated on the Drawings.
            b) Interior operating rod material: Indicated on the Drawings.
            c) Casing guard material: Indicated on the Drawings.
            d) Principal interior operating parts material: brass and/or bronze and removable from yard hydrant for servicing without excavation.
         4) Provide 4 Spoke, Ball Wheel Handle operated.

C. Freezeless post hydrants:
   1. Manufacturers: The following or equal:
      a. Kupferle Foundry Company:
         1) #2 Eclipse Post Hydrant.
      b. Mueller Company:
         1) #A-411 Post Hydrant.
      c. Murdock Company:
         1) #M-200 Post Hydrant.
   2. Design:
      a. Self draining, non-freezing, compression type with a 2-3/16 inch valve opening.
      b. Inlet connection size: Indicated on the Drawings.
      c. Outlet connection size: Indicated on the Drawings.
      d. Materials:
         1) Exterior casing pipe material: Indicated on the Drawings.
         2) Interior operating rod material: Indicated on the Drawings.
         3) Top stock material: Indicated on the Drawings.
         4) Principal interior operating parts material: Brass and/or bronze and removable from hydrant for servicing without excavation.
      e. Provide 1-1/2 inch pentagon operating nut operated by a hydrant wrench or 10 inch hand wheel:
         1) Manufacturers: One of the following or equal:
            a) Kupferle Foundry Company.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and manufacturer’s instructions.

B. Mount yard hydrants on minimum 1 inch supply pipe or size indicated on the Drawings.

C. Mount Post hydrants on minimum 2 inch supply pipe or size indicated on the Drawings.

D. Set yard and post hydrants in 4 cubic feet of 3/4 inch minimum crushed stone surrounding valve body to allow for proper drainage.
   1. Install in accordance with AWWA recommendations for hydrants.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services from each manufacturer for all valves supplied,
   1. As specified in Section 15110.
   2. On site services.

Manufacturer Rep Onsite							
Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
X	X	X	X	X	X	X	

   3. Source testing.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Non-lubricated.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 09960 - Coatings.
      c. Section 15110 - Valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.

B. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 536 – Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Section 01330 and Section 15110:
   1. Product data.
   2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 NON-LUBRICATED PLUG VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik, "PEC".
   2. Clow Valve.

B. Design:
   1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material which operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent.
   3. Where piping system is specified as glass-lined, provide glass-lined valve.
   4. Compression washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   5. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
   6. Clearly mark valves to indicate their open and closed positions.
   7. Provide valves with ends as required by piping details indicated on the Drawings.

C. Materials:
   1. Body and plug: ASTM A 126, Class B, cast-iron, with plug face of Buna N material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90 percent nickel and minimum thickness of 1/8 inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel.
   5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

2.02 MULTI-PORT PLUG VALVES

A. Manufacturers: One of the following or equal:
   1. DeZurik, PTW.
   2. Milliken, equivalent product.

B. Design: Non-lubricated tapered plug type including plugs faced with neoprene, body of cast iron, and stainless steel bearings in the upper and lower journal areas.

C. Furnish valves with single style plug or as required.

2.03 VALVE OPERATORS

A. Furnish valves with an operating wrench or worm gear operator:
   1. Equip valves 4 inch nominal size and smaller with a lever operator.
   2. Equip valves 6 inch nominal size and larger with a worm gear operator.

2.04 COATING

A. Coat interior metal surfaces as specified in Section 15110.

B. Coat exterior metal surfaces as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 and the manufacturer's instructions.

B. Install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.

C. Lubrication: Lubricate plug valves and fill extended lubricant pipes with lubricant suitable for service intended.

D. Install valves so that in the open position the plug is located in the top half of the valve body.

END OF SECTION

SECTION 15117

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Solenoid valves.
   2. Plastic body diaphragm valves.
   3. Pinch valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 15082 - Piping Insulation.
      c. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.

B. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

C. American Water Works Association (AWWA):
   1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
   2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).

D. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   3. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A 536 - Standard Specification for Ductile Iron Castings.
   5. B 584 - Standard Specification for Copper Alloy Sand Castings for General Application.
   6. D 2000 - Standard Classification System for Rubber Products in Automotive Application.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA Type 4 enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Section 01330 and Section 15110:
   1. Product data.
   2. Operation and maintenance data.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.06 DELIVERY STORAGE AND HANDLING

A. Protect valves from damage during handling and installation.

PART 2 PRODUCTS

2.01 SOLENOID VALVES

A. 2-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Company, Series 8210.
      b. Skinner Electric Valve Division, Series C.

B. 3-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Company, Series 8320.
      b. Skinner Electric Valve Division, Type A4.

C. 4-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Company, Bulletin 8344.
      b. Skinner Electric Valve Division, Series V9.

D. Design:
   1. Valves: Suitable for service under the following conditions:
      a. Fluid: Reclaimed Water.
      b. Temperature of fluid: 80 degrees Fahrenheit.
      c. Piping test pressure: 125 pounds per square inch gauge.
   2. Unless otherwise indicated on the Drawings, provide valves that:
      a. Minimum NEMA Type 4 enclosure.
      b. 120 VAC operation.
      c. Suitable for use as indicated on the Drawings.
      d. Minimum Class F coil insulation.

3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
4. Furnish with manual/bypass operators.

E. Materials:
1. Body: Brass or bronze.
2. Seats: Resilient material.

2.02 PLASTIC BODY DIAPHRAGM VALVES

A. Type of service: Use plastic body diaphragm valves in the following services:
1. Sodium hypochlorite.

B. Manufacturers: One of the following or equal:
1. Simtech.
2. Chemtrol.
3. Georg Fischer Piping Systems.

C. Materials:
1. Body: PVC with reinforcing ribs at body and end connections.
2. Diaphragm: Unless otherwise specified below, provide 2 diaphragm layers - Teflon® diaphragm with EPDM backing or other material suitable for the intended use.
   a. For sodium hypochlorite service: 3 diaphragm layers, Teflon® (PTFE), PVDF, and ethylene-propylenediene (EPDM) or Viton backing cushion.
3. Handwheel: Polypropylene.
4. Sleeve: Bronze or cast iron.
5. Stem: Stainless steel.
6. Bolt, nut, and washer: Stainless steel.
7. Thrust bearing: Teflon® disc or carbon steel.
8. End connector: PVC.
9. End connector seal (flange gasket): Suitable for the intended use unless otherwise specified below.
   a. For sodium hypochlorite and sodium bisulfite solution service: Hypalon 1/8-inch thick gaskets.
10. O-rings: Viton.
11. Position indicator: Carbon steel.

D. Valve design:
1. End connections: Flanged.
2. Operator handle: Handwheel, with position indicator and adjustable travel stop to prevent overtightening. Provide acrylic stem cap.
3. Diaphragm valves: Weir type.
4. Pressure: 150 pound per square inch gauge at 70 degrees Fahrenheit.

2.03 PINCH VALVES

A. Manufacturers: One of the following or equal:
1. Red Valve Company, Series 80 with Type DW sleeves.
2. RKL Controls, Inc., Series KEFR.
3. Onyx Valve, equivalent product.

B. Design: Open frame handwheel type.

C. Materials:
   1. Sleeve material: Suitable for operation requiring continuous opening and closing of the valve.
   2. Sleeves: Teflon® reinforced with butyl nylon or other equivalent reinforcing material.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 in accordance with manufacturer's published instructions.

B. Install sensing line insulation as specified in Section 15082.

C. Plastic body diaphragm valves for sodium hypochlorite service:
   1. When valves are installed horizontally, install valves with valve stem position rotated as necessary such that no internal valve obstruction prevents the passage of vapors traveling along the top of adjacent piping from traveling through the valve.

END OF SECTION

SECTION 15118

PRESSURE REDUCING AND PRESSURE RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water, air, and chemical service.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

B. ASTM International (ASTM):
   1. A 48 - Standard Specification for Gray Iron Castings.
   2. A 536 - Standard Specification for Ductile Iron Castings.

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Section 01330 and Section 15110:
   1. Product Data.
   2. Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 WATER PRESSURE RELIEF VALVES

A. Water pressure relief valves:
   1. Manufacturers: One of the following, or equal:
      a. Watts ACV Series 116.
      b. Cla-Val Model 50-01.

2. Design:
    a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
    b. Rated for 125 pounds per square inch gauge.
    c. Pilot line: Equipped with a strainer.
    d. End connections:
        1) 2 1/2 inch and smaller: Screwed.
        2) 3 inch and larger: 150 pound rated flanges in accordance with ASME B16.42.
3. Materials:
    a. Body and cover: Cast iron ASTM A 48 or Ductile Iron ASTM A 536.
    b. Valve trim: Bronze.
    c. Pilot control: Cast bronze with Series 303 stainless steel trim.
    d. Diaphragm: Nylon reinforced Buna N.

2.02 AIR PRESSURE REGULATING VALVES

A. Air pressure regulating valves:
1. Manufacturers: The following, or equal:
    a. Fisher Controls Company, Series 95.
    b. Or equal.
2. Type: Self-operated air pressure regulator for high capacity installations.
3. Design:
    a. Size: Same size as pipe size indicated on the Drawings.
    b. Inlet pressure rating: Not less than 600 pounds per square inch gauge.
    c. End connections: Screwed or flanged, compatible with joint type specified for the piping system.
    d. Internal pressure relief capability for minor seat leakage.
4. Materials:
    a. Body: Cast iron.
    b. Diaphragm and disc: Fluoroelastomer suitable to 300 degrees Fahrenheit.
    c. Valve trim: Type 416 stainless steel.
5. Output pressure:
    a. Spring range: Provide lowest spring range that will allow adjustment to the specified output pressure.

2.03 PRESSURE RELIEF VALVES FOR CHEMICAL SERVICE

A. Manufacturers: One of the following or equal:
1. Plast-O-Matic, Series RVT, RVDT or TRVDT.
2. GRIFFCO.

B. Materials:
1. Valve body: CPVC or PVC.
2. U-cup seals:
    a. Polymer service: Viton.
    b. Hypochlorite service: Viton.
    c. Caustic service: EPDM.
    d. Sodium Bisulfite: EPDM.
3. Adjusting bolt, locknut, control spring and fasteners: stainless steel.

C. Design:

1. Pressure rating: Not less than 150 pounds per square inch.
2. In-line or angle pattern design, size as indicated on the Drawings.
3. End connections:
   a. 1 inch and smaller: Threaded.
   b. Larger than 1 inch: Flanged.
4. Relief set point:
   a. Externally adjustable without removing valve from piping system.
   b. Set valve to open at 10 pounds per square inch more than pump discharge pressure at operating point, or as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with Section 15110.

END OF SECTION

SECTION 15119

AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Air release valves, air and vacuum valves, and air vents.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME).
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA).

C. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   3. A 270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
   4. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

A. Shop drawings: Submit the following information as specified in Section 01330 and Section 15110:
   1. Product data.
   2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 AIR RELEASE VALVES, SEWAGE SERVICE

A. Manufacturers: One of the following or equal:
   1. ARI.
   2. Valve and Primer Corporation, APCO Number 400.
   3. Multiplex Manufacturing Company, Crispin Series S.

B. Design:
   1. Operation: Release accumulated air in sewage pipelines operating under pressure. After entrained air escapes through the orifice, the orifice is plugged by a needle mounted on a compound lever mechanism.
   2. Internal components removable through top cover without removing valve from pipeline.
   3. Pressure rating: 150 pounds per square inch.
   4. Orifice size: 1/4-inch diameter.
   5. Connections: Threaded, 2-inch diameter inlet and threaded, 1/2-inch diameter outlet.

C. Accessories:
   1. Inlet shutoff valve. Utilize eccentric plug valve.
   2. 2 blowoff valves for backflushing.
   3. 10 feet of hose with quick disconnect couplings.

D. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.
   3. Needle: Buna-N.

2.02 AIR AND VACUUM VALVES, SEWAGE SERVICE

A. Select type of sewage-service air and vacuum release valve from the 2 options provided. Furnish only 1 style of air and vacuum release valve for the entire project.
   1. Option 1: Float activated air and vacuum release valve.
   2. Option 2: Anti-surge type air and vacuum release valve.

B. Option 1: Float activated air and vacuum release valves.
   1. Manufacturers: One of the following or equal:
      a. ARI.
      b. Multiplex Manufacturing Company, Crispin SA Series.
      c. Valve and Primer Corporation, APCO Series 401.
   2. Design:
      a. Operation: Release air from pipeline as pipeline is filled and allow air to enter pipeline as pipeline is drained.
      b. Internal components removable through top cover without removing valve from pipeline.
      c. Pressure rating: 150 pounds per square inch.
   3. Accessories:
      a. Inlet shutoff valve. Utilize eccentric plug valve.
      b. 2 blowoff valves for backflushing.
      c. 10 feet of hose with quick disconnect couplings.
   4. Connections: 2-inch threaded inlet and 1-inch threaded outlet.

5. Materials:
    a. Body: Cast iron.
    b. Float: Type 316 stainless steel.
    c. Seat: Buna-N.
6. Connections: Flanged connections conforming to ASME B16.1 Class 250 and ASME B16.5 Class 300 standards.
7. Performance: Leaktight past the orifice seal at operating pressures to 200 pounds per square inch gauge.
8. Materials:
    a. Body: Type 316 stainless steel.
    b. Float: HDPE.
    c. Seats: EPDM.

2.03 COMBINATION AIR VALVES - SEWAGE SERVICE

A. Manufacturers: One of the following or equal:
1. ARI.
2. Valve and Primer Corporation, APCO Series 440.
3. Multiplex Manufacturing Company, Crispin Series US.

B. Design:
1. Operation: Automatic exhaust and intake of large quantities of air during filling and draining of pipelines, respectively, and release of accumulated air while pipeline is under pressure.
2. Design: Utilize compound lever system in conjunction with large and small orifices.
3. Internal parts removable through top cover without removing valve from pipeline.
4. Pressure rating: 150 pounds per square inch.
5. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
6. Accessories:
    a. Inlet shutoff valve.
    b. 2 blowoff valves for backflushing.
    c. 10 feet of hose with quick disconnect couplings.

C. Materials:
1. Body: Cast iron.
2. Float: Type 316 stainless steel.
3. Needle: EPDM.

2.04 AIR AND VACUUM VALVES, WATER SERVICE

A. Manufacturers: one of the following or equal:
1. Valve and Primer Corporation, APCO Number 140 Series.
2. ValMatic Valve and Manufacturing Corp., equivalent model.
3. Multiplex Manufacturing Company, Crispin A Series.

B. Design:
1. Minimum performance requirements:
    a. Air in-flow through valve: As indicated on the Drawings
    b. Air exhaust through valve: As indicated on the Drawings.
2. Pressure rating: Suitable for service under operating pressures equal to and less than 250 pounds per square inch gauge.

3. Inlet: Screwed, 2-inch size.

C. Materials:
   1. Body: cast iron.
   2. Float: stainless steel, Type 316.

2.05 COMBINATION AIR VALVES, WATER SERVICE

A. Manufacturers: one of the following or equal:
   1. Valve and Primer Corporation, APCO No. 140C Series
   2. ValMatic Valve and Manufacturing Corp., equivalent model.
   3. Multiplex Manufacturing Company, Crispin UL Series.

B. Design:
   1. Operation: Automatic exhaust of large quantities of air from pipelines during filling and draining and release of accumulated air while pipeline is under pressure.
   2. Utilize compound lever system in conjunction with large and small orifices.
   3. Internal parts removable through top cover without removing valve from pipeline.
   4. Pressure rating: 150 pounds per square inch.
   5. Inlet:
      a. Screwed: 1-3 inch size.
      b. Flanged: 4-10 inch size.
   6. Outlet: Screwed or flanged.

C. Materials:
   1. Body: cast iron.
   2. Float: stainless steel, Type 316.
   3. Needle: Buna-N.
   4. Lever frame: cast iron or Delrin.

2.06 VERTICAL TURBINE PUMP AIR AND VACUUM VALVE

A. Manufacturers: One of the following, or equal:
   1. Valve and Primer Corporation, APCO, Series 140DAT.
   2. Val-Matic, Series 100WS-T.

B. Design:
   1. For vertical turbine pump discharge piping, where the required air and vacuum valve size is 3-inch diameter or less (for 4-inch diameter or larger use slow closing air and vacuum valve as specified in paragraph 2.04).
   2. Operation: Vent large quantities of air from pump column to atmosphere to prevent forcing air in the system piping upon pump start-up and allow air to enter the pump column on pump stop to prevent vacuum forming in the pump suction column.
   3. Valve shall be fitted with a water diffuser.
   4. Valve connections shall be either screwed or flanged.
   5. Valve shall include a throttling device on the discharge side of the valve.
   6. Valve shall close tight when liquid enters.
   7. Baffle shall be used to prevent direct impact of air and water.
   8. Valve shall be fitted with an air release.
   9. Valve shall be filled with an inlet isolation butterfly valve.

C. Materials:
   1. Body and Cover: Cast iron, ASTM A126, Grade B.
   2. Baffle: Cast iron, ASTM A48, Class 30.
   3. Float and Trim: Stainless steel, ASTM A240, Type 304.
   4. Seat: Buna-N.
   5. Water Diffuser: Brass, ASTM B16.
   6. Throttling Device:
      a. Housing: Malleable iron, ASTM A47.
      b. Adjusting Screw and Nut: Stainless steel, ASTM A276, Type 304.
      c. Plug: Stainless steel.
   7. Exterior Paint: Phenolic primer red oxide approved by the United States Food and Drug Administration for contact with potable water.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 and manufacturer's instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Piping specialties including:
   1. Flexible rubber connections.
   2. Slip type expansion joints.
   3. Rubber expansion joints.
   4. Transition fittings.
   5. Pipe saddles.
   6. Tapping sleeves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 01782 - Operation and Maintenance Data.
      d. Section 15052 - Common Work Results for General Piping.
      e. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM).
   1. A 148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A 536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Product data:

1. Submit for each piping specialty:
    a. Shop drawings detailing dimensions and materials.
    b. Manufacturer's published installation instructions.

C. Provide vendor operation and maintenance manual as specified in Section 01782.

D. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756.

E. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Bellows type expansion joints and vibration control joints:
1. Protect joints against damage during packing, shipping, and installation, and also during pressure test.
2. Lock expansion joints against movement until pressure tests are completed.
3. Replace damaged expansion joints with new and undamaged expansion joints.

B. Washdown monitors:
1. Protect washdown monitors and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 FLEXIBLE RUBBER CONNECTIONS

A. Manufacturers: One of the following or equal:
1. Mercer Rubber Company, Type 150 Vibraflex.
2. Red Valve Company, Inc., Part Number P-5.

B. Provide flexible rubber connections with 3/8 inch thick EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.

C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.02 SLIP TYPE EXPANSION JOINTS

A. Expansion joints for steam cleaned piping:
1. Manufacturers: One of the following or equal:
    a. BTR, Inc./Smith-Blair, Inc., Number 612 with slip pipe and without limit rods.
    b. Dresser Industries, Inc., Style 63, Type 2.
2. Line and coat slip pipe and interior of body with fusion-bonded epoxy of minimum 0.012-inch thickness.
3. Packing: Suitable for temperatures greater than 212 degrees Fahrenheit.

B. PVC expansion joints:
1. Flexible bellows type with equalizing rings.

2. Manufacturers: One of the following or equal:
    a. Flo Control, Flo-Span.
    b. Chemtrol.
3. Materials: PVC with EPDM O-ring.
4. Design:
    a. 150 pound per square inch pressure rating.
    b. Double O-ring seal.
    c. Axial travel: Not less than 1.5 inches.
    d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.

2.03 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible hose:
1. Manufacturers: One of the following or equal:
2. General:
    a. Type: Flexible stainless steel hose
        1) Unbraided for pressures up to 150 pounds per square inch.
        2) Single braided for pressures up to 225 pounds per square inch.
        3) Double braided for pressures up to 360 pounds per square inch.
    b. End connections: Flanged, or as needed to comply with the specified type of joint
        1) Sizes 2 1/2-inches and smaller may have threaded nipples.
        2) Sizes 2-inches through 12-inches may have grooved ends.
3. Design:
    a. Open pitch spacing of corrugation.
    b. 1 fixed and 1 floating raised face flanged end connection.
    c. Able to withstand up to 1-inch offset motion from centerline.
4. Materials:
    a. Hose: Type 316 stainless steel.
    b. Flanges: Carbon steel.VIBRATION CONTROL JOINTS

2.04 TRANSITION FITTINGS

A. Manufacturers: One of the following or equal:
1. Spears.

B. Materials:
1. Slip socket: Schedule 80 PVC.
2. Collar: Type 316 stainless steel.
3. Threaded insert: Type 316 stainless steel.

2.05 PIPE SADDLES

A. Manufacturers: One of the following or equal:
1. BTR Inc./Smith-Blair, Inc., Style 317.
2. Romac Industries, Inc., Style 202S.

B. Materials:
1. Pipe saddles: Ductile iron**.**
2. Straps, bolts, and nuts: Type 304 stainless steel with Teflon coating on nuts.
3. Gaskets: EPDM.

2.06 TAPPING SLEEVES

A. Manufacturers: One of the following or equal:
   1. BTR, Inc./Smith-Blair, Inc., Style 622.
   2. Romac Industries, Inc., Style FTS 420.

B. Materials:
   1. Tapping sleeves: Steel construction.
   2. Bolts and nuts: Type 304 stainless steel.
   3. Nuts: Teflon coated.
   4. Gaskets: EPDM.
   5. Size of tapped boss: As indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Expansion control joints:
   1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
   2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
   3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
      a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
   4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
   5. Provide control rods and additional guides where indicated on the Drawings, but at no greater intervals than recommended by the joint manufacturer in published instructions.
   6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

B. Transition couplings:
   1. Application:
      a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
   2. Install transition-coupling products specifically designed and manufactured for that application.

C. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

D. Tapping sleeves:
   1. Verify existing pipe material and outer diameter prior to ordering materials.

2. Coat threads on bolts with anti-gall coating prior to installation.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer(each) services for each type of piping specialty:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Source Testing (Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Non-Witnessed	4	2	1	2	1	1	Not Required	

C. Functional Testing:
   1. Pressure testing as specified in Sections 15052 and 15956.

END OF SECTION

SECTION 15121

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-up.
      c. Section 01782 - Operation and Maintenance Data.
      d. Section 09960 - High-Performance Coatings.
      e. Section 15052 - Common Work Results for General Piping.
      f. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
   3. C606 – Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.
   2. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

4. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
5. A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
6. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
7. A 449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
8. A 536 - Standard Specification for Ductile Iron Castings.
9. A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
10. A 576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
11. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
12. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
13. F 594 - Standard Specification for Stainless Steel Nuts.

E. NSF International (NSF).
1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Product data:
1. Shop drawings, detailing dimensions, and materials.
2. Piping layout drawings: Coordinate preparation of required piping layout drawings to show coupling sizes.

C. Provide vendor operation and maintenance manual as specified in Section 01782.
1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inch in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756.

E. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

PART 2 PRODUCTS

2.01 GENERAL

A. Known acceptable manufacturers are listed by specific products.

B. Provide references as specified in this Section by specific product.

C. Manufacturer’s representatives requirements as specified in Section 01756 and this Section by specific product.

D. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. Low-pressure and high-pressure air, steam, hot water: EPDM.
      b. All other piping applications: EPDM.

E. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Tapecoat Company, Inc., T.C. Mastic.
      b. Kop-Coat Company, Inc., Bitumastic Number 50.
   2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Industries, Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool:
         1) AWWA C207 steel pipe:
            a) ASTM A 53 for sizes 3 inches to 12 inches.
            b) ASTM A 36 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A 536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A 36 or A 53.
      c. Follower ring: Ductile iron in accordance with ASTM A 536.
      d. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
      e. Tie rods: High tensile steel in accordance with ASTM A 193 Grade B7.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

B. Flanged coupling adapters: 12-inch size and smaller:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 227.
      b. Romac Industries, Inc., Style FCA501.
      c. Smith-Blair, Inc., Series 912.
   2. Materials:
      a. Flanged body: Ductile iron in accordance with ASTM A 536.
      b. Follower ring: Ductile iron in accordance with ASTM A 536.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flanged coupling adapters: Greater than 12-inch size:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 128-W.
   b. Romac Industries, Inc., Style FC400.
   c. Smith-Blair, Inc., Series 913.
2. Materials:
   a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

D. Flexible couplings:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 253.
   b. Romac Industries, Inc., Style 501.
   c. Smith-Blair, Inc., Series 441.
2. Materials:
   a. Center rings: Ductile iron in accordance with ASTM A 536.
   b. Follower rings: Ductile iron in accordance with ASTM A 536.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F 593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per Pipe Couplings for Steel Piping

E. Restrained flange coupling adapter:
   1. Manufacturers: One of the following or equal:
      a. Romac Industries, Inc., Style RFCA.
      b. Star Pipe Products, 3200 StarFlange.
      c. .
   2. Materials:
      a. Flange and flanged body: Ductile iron in accordance with ASTM A 536.
      b. Follower ring: Lug type restraint system.
         1) Follower ring: Ductile iron in accordance with ASTM A 536.
         2) Restraining lugs: Ductile iron in accordance with ASTM A 536.
            a) Designed to contact the pipe and apply forces evenly.
         3) Restraining bolts:
            a) Ductile iron in accordance with ASTM A 536.
            b) Bolt heads shall be designed to twist off when the proper torque has been applied.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F 593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
   5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

F. Grooved joint couplings:
   1. Manufacturers:
      a. Victaulic Company, Series 31 or equal.
   2. Materials:
      a. Housings: Ductile iron in accordance with ASTM A 536.
      b. Gasket:
         1) FlushSeal® type, or equal. Elastomer in accordance with ASTM D 2000.
         2) Neoprene or BUNA-N.
      c. Bolts and nuts: Electroplated steel in accordance with ASTM A 449.
      d. Coating: As specified in Section 09960.
   3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
   4. For connection to IPS steel pipe sizes, Victaulic Style 307.

2.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer(each) services for each type of pipe coupling:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Source Testing (Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Non-Witnessed	4	2	1	2	1	1	Not Required	

C. Functional Testing:
   1. Pressure testing as specified in Sections 15052 and 15956.

END OF SECTION

SECTION 15125

STRAINERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Strainers.

B. Related section:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 01782 - Operation and Maintenance Data.
      d. Section 15052 - Common Work Results for General Piping.
      e. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A 420 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service.

B. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Product data:
   1. Shop drawings, detailing dimensions, and materials.
   2. Installation instructions.

C. Provide vendor operation and maintenance manual as specified in Section 01782.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type strainer. Include information on valves for mechanically-cleaned strainers.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756.

PART 2 PRODUCTS

2.01 Y-TYPE STRAINERS

A. Y-type strainers 4 inches and larger in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged.
      c. Screens: Brass or Type 304 stainless steel.
   2. Suitable for following minimum pressure conditions:
      a. Steam service: 250 pounds per square inch gauge.
      b. Water, oil, and gas service: 200 pounds per square inch gauge.
   3. Perforated screens:
      a. Openings: 0.045 inches.
      b. Active screen opening to pipe area ratio: 2.8, minimum.
      c. Free area: 37 percent minimum.
   4. Manufacturers: One of the following or equal:
      a. Armstrong International Inc., Code A1.
      b. ITT/Hoffman, 460 Series.

B. Y-type strainers less than 4 inches in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged or threaded.
      c. Screen: Brass or Type 304 stainless steel.
   2. Suitable for minimum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: One of the following or equal:
      a. Armstrong, Y-Type Strainer.

2.02 BASKET TYPE STRAINERS

A. Provide basket type strainers single or duplex as indicated on the Drawings.

B. Materials:
   1. Bodies: Cast iron or cast steel.
   2. Baskets: Low-zinc bronze or stainless steel.

C. Pressure rating: Where not otherwise indicated on the Drawings, 125 pounds per square inch gauge, minimum.

D. Connections: Threaded or flanged, as required.

E. Covers:
   1. For strainers 6 inches and smaller in size, secured by yokes or similar quick opening devices.
   2. For strainers larger than 6 inches in size, bolted or hinged and bolted with slotted washers so that bolts or nuts need not be completely removed to open the strainer.

3. Provide lifting eyes on covers weighing more than 50 pounds.

F. Baskets:
   1. Screen: Mesh or perforated sheet.
   2. Openings: Not greater than ***1/2*** inch.
   3. Free area: Not less than 30 percent.
   4. Free area to pipe ratio: Not less than 3.

G. Provide duplex strainers with tapered plug transfer valve or with gate type transfer valves.
   1. Where action on two valve actuators is required to transfer operation from one chamber to the other, provide actuators mechanically linked for simultaneous operation.

H. Manufacturers:
   1. Single basket strainers: One of the following or equal:
      a. Fluid Engineering, Series 528B.
      b. Mueller Steam Specialty.
   2. Double basket strainers: One of the following or equal:
      a. Fluid engineering, Series 534 for sizes 1-1/2 inch to 8 inch, and Series 424 for sizes 10 inch and larger.
      b. Mueller Steam Specialty.
   3. Basket strainers for chemical service:
      a. Dual or simplex as indicated on the Drawings; baskets and bodies PVC; gaskets Viton or EPDM as required for the chemical service; basket mesh size to be specified by the Engineer during shop drawing review.
      b. Manufacturer: Hayward.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with the manufacturer's recommendations.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer(each) services for each type of strainer.
   1. Provide Manufacturer’s Certificate of Source Testing.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.
   3. Training and other on-site services.
      a. Mechanically-cleaned only

b.

SECTION 15211

DUCTILE IRON AWWA C151 PIPE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, fittings, gaskets, and pipe linings and coatings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 02318 - Trenching.
      b. Section 15052 - Basic Piping Materials and Methods.
      c. Section 15121 - Pipe Couplings.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   6. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   7. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   8. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
   9. C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
   10. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
   1. A 47 - Standard Specifications for Ferritic Malleable Iron Castings.
   2. A 183 - Standard Specifications for Carbon Steel Track Bolts and Nuts.

3. A 536 - Standard Specifications for Ductile Iron Castings.
4. C 283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
5. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

E. Ductile Iron Pipe Research Association (DIPRA):
1. Thrust Restraint Design Manual.

F. NACE International (NACE):
1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. National Association of Pipe Fabricators, Inc. (NAPF):
1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Steel Structures Painting Council (SSPC):
1. PA-2 - Measurement of Dry Coating Thickness With magnetic Gages.

1.03 SYSTEM DESCRIPTION

A. Thrust restraint system design:
1. Design restrained joint thrust restraint system.
2. Determine the length of pipe that must be restrained on each side of the focus of a thrust load in accordance with the procedures and criteria established by the DIPRA Thrust Restraint Design Manual as specified in Piping Schedule in Section 15052 and the following additional criteria:
   a. Design pressure: Test pressure.
   b. Laying condition: Type 5 in accordance with AWWA C150.
   c. Soil designation: Clay 2 as defined by DIPRA.
   d. Unit friction resistance: Based upon polyethylene encasement of pipe.
   e. Safety factor: 1.5 (for thrust restraint calculations only).

1.04 SUBMITTALS

A. Product data: Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

B. Shop drawings:
1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, connections to structures, and thrust restraint system layouts.
2. Thrust restraint systems: Calculations and layout for restrained joint thrust restraint systems.

C. Design calculations:
1. Calculations for thrust restraint system design.

D. Test reports:
   1. Manufacturer's test reports for glass lining certifying successful performance of holiday detection tests. This documentation shall identify each piece by mark designation, and show the actual test results during the final inspection by the manufacturer prior to shipment. Acceptance criteria for glass lining shall be as specified under Field Quality Control.
   2. Manufacturer's test results for glass lined pipe-certifying compliance with specified material requirements for glass lining.
   3. Submit Coating Manufacturer's Technical Representative's reports.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Lining manufacturers: For piping specified to receive glass or epoxy lining, use only a lining manufacturer having a minimum of 5 years experience supplying this type of product to the wastewater and water industry.
   2. Welded on outlets: The pipe manufacturer shall have a minimum of 5 years experience in the fabrication and testing of outlets of similar size and configuration similar to those used on the Project.

B. Pre-installation meeting:
   1. Arrange for Coating Manufacturer's Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation. Do not drop piping material from cars or trucks. Lower piping by mechanical means. Do not drop or pound pipe to fit grade.

C. Glass-lined pipe and fittings must be handled only from the outside. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Typical type: In accordance with AWWA C150 and AWWA C151. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052.
   2. Type with screw-on flanges: In accordance with AWWA C115 with minimum special thickness Class 53 wall thickness as required for screw-on flanges. Special thickness class as indicated in the Piping Schedule as specified in Section 15052.
   3. Type with grooved couplings: Special thickness class as indicated in the Piping Schedule as specified in Section 15052.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
         1) Ductile iron.
         2) Long hub, threaded, and specially designed for ductile iron pipe.
         3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts: As specified in Section 15052.
      e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052.
   2. Grooved joints: In accordance with AWWA C606, as complemented and modified below, radius-cut type, with following components:
      a. Couplings: Rigid type, cast from ductile iron in accordance with ASTM A 536, Grade 65-45-12, or malleable iron in accordance with ASTM A 47, Grade 32510.
      b. Bolts and nuts: In accordance with ASTM A 183, Grade 2.
      c. Gaskets: Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure. Material to be used for following services:
         1) For liquid service: NBR.
         2) For air service: Fluoroelastomer.
         3) For hot water service: EPDM.
      d. Fittings: In accordance with AWWA C606, rigid radius-cut groove:
         1) Center-to-center dimensions: In accordance with AWWA C110.
         2) Wall thickness and other characteristics: In accordance with AWWA C606.
      e. Flanged unit connections: Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
   3. Mechanical joints: In accordance with AWWA C111.
   4. Push-on rubber gasket joints: In accordance with AWWA C111.

5. Integrally restrained mechanical joints:
    a. Application: Where designation Mech Rest. MJ is specified in the Piping Schedule provided in Section 15052 supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations. Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.
    b. Design: Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts. Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
    c. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
        1) American Cast Iron Pipe Company, MJ Coupled Joint.
        2) Pacific States Cast Iron Pipe Company, Lock Mechanical Joint.
6. Integrally restrained push-on joints:
    a. Application: Where designation restrained push-on is specified in the Piping Schedule provided in Section 15052, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations. Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
    b. Design:
        1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
        2) Suitable for the following working pressures:
            a) For 4 through 24-inch pipe: 350 pounds per square inch gauge.
            b) For 30 through 54-inch pipe: 250 pounds per square inch gauge.
    c. Manufacturers: One of the following or equal:
        1) United States Pipe and Foundry Company, TR Flex.
        2) Pacific States Cast Iron Pipe Company, Thrust Lock.
        3) American Cast Iron Pipe Company, Flex Ring or Lok-Ring.
    d. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. Fittings:
1. Ductile iron in accordance with AWWA C110.
2. Joint type: Same as that of the associated piping as specified in Section 15052.
3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

D. Pipe linings and coatings:
1. Cement-mortar lining:
    a. In accordance with AWWA C104, apply cement-mortar on clean bare metal surfaces. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
    b. Minimum lining thickness: Standard in accordance with AWWA C104.
    c. Type of cement: Type II.
2. Asphaltic seal coat:
    a. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating. Apply in accordance with AWWA C151.

3. Glass lining:
    a. Manufacturers: One of the following or equal:
        1) Water Works Manufacturing, Ferrock MEH-32 Lining.
        2) Vitco Corporation, SG-14 Lining.
    b. Material: Special glasses and inorganic materials suited for lining of sewage, sludge, and scum piping with the following characteristics:
        1) Thickness: 0.008 to 0.012 inch.
        2) Hardness: 5 to 6 on the Mohs Scale.
        3) Density: 2.5 to 3.0 grams per cubic centimeter, measured in accordance with ASTM D 792.
        4) Thermal shock resistance: Capable of withstanding 350 degrees Fahrenheit change from 430 degrees Fahrenheit to 80 degrees Fahrenheit without crazing, blistering, or spalling.
        5) Gloss retention: Capable of retaining gloss after immersion in an 8 percent sulfuric acid solution at 148 degrees Fahrenheit for 10 minutes.
        6) Weight loss: Maximum 3 milligrams per square inch when tested in accordance with ASTM C 283.
    c. Fabrication:
        1) Use piping that is suitable for glass lining with minimum Class 53 wall thickness after application of glass lining.
        2) Machine interior of pipe. Bore or grit blast in accordance with NAPF 500-03 prior to application of glass lining.
        3) Screw factory assembled flanges on pipe, align boltholes, and flange faces, unless otherwise specified.
        4) Apply lining to surfaces free of chemicals.
        5) Place piping in furnaces specially designed for heating piping until glass melts and fuses with a integral molecular bond to the base metal.

2.02 POLYETHYLENE ENCASEMENT

A. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105, or

B. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
    1. Install ductile iron piping in accordance with AWWA C600, modified as specified in Section 15052.
    2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318.

B. Polyethylene encasement:
    1. Wrap all buried ductile iron pipe and fittings in 2 layers of loose polyethylene wrap in accordance with AWWA C105.

2. Polyethylene encasement shall be continuous and terminated neatly at connections to below grade equipment or structures.
3. At wall penetrations, extend encasement to the wall and neatly terminate.
4. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
5. When rising vertically in unimproved areas, extend encasement 6 inches above existing grade and neatly terminate.
6. Repair tears and make joints with 2 layers of plastic tape.
7. All work shall be inspected prior to backfilling of pipe and associated items.

C. Joints:
1. Install types of joints as specified in the piping schedule provided in Section 15052.
2. Mechanical joints are not acceptable in above ground applications.
3. Field closure for restrained push-on pipe:
   a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
4. Grooved joints:
   a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 or indicated on the Drawings.
   b. Assemble grooved joints in accordance with manufacturer's published instructions.
   c. Support grooved-end pipe in accordance with manufacturer's published instructions. Install at least 1 support between consecutive couplings.

D. Tapping ductile iron pipe:
1. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
   a. Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	**Pressure Class**				
	150	**200**	**250**	**300**	**350**
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

   b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.

c. Two layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

3.02 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
   1. Test as specified in Section 15052.
   2. Do not test sections longer than 1/2 mile in total pipe length.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

C. Verify that interior surfaces of glass lined pipe and fittings have continuous coverage:
   1. Verify with low voltage wet sponge holiday detector in accordance with NACE SP0188.
   2. Discard glass lined ductile iron piping and fittings with voids or casting anomalies that represent more than 0.01 percent of the total glassed surface. No more than 2 pinholes per fitting or an average of 5 or less pinholes per 20 feet of pipe.
   3. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 15230

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15211 - Ductile Iron Pipe: AWWA C159.
      e. Section 15956- Piping Systems Testing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
   1. D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
   2. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D 1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. D 1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
   5. D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   6. D 2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   7. D 2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   8. D 2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
   9. D 2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   10. D 2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

11. D 2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride)(PVC) Pipe and Fittings.
12. D 3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
13. D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
14. D 3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
15. D 3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.
16. D 4101 – Standard Specification for Polypropylene Injection and Extrusion Materials.
17. F 438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
18. F 439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
19. F 441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
20. F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
21. F 493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
22. F 645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
23. F 679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
24. F 714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
   1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches (100 mm Through 300 mm), for Water Transmission Distribution.

D. NSF International (NSF).

E. Plastics Pipe Institute (PPI):
   1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. ID: Inside diameter of piping or tubing.

F. NPS: Nominal pipe size followed by the size designation.

G. NS: Nominal SIZE of piping or tubing.

H. PE: Polyethylene.

I. PP: Polypropylene.

J. PVC: Polyvinyl chloride.

K. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.
   3. Polyethylene pipe submittals: Include:
      a. Installation equipment including details on fusion machine used to join polyethylene pipe sections.
      b. Qualifications of installation crew for use of the fusion machine used for joining polyethylene pipe.

C. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756. Include as applicable:
   1. Date of manufacture of plastic pipe and tubing for each lot delivered.
   2. Solvent cement manufacturer's report and certification

D. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.05 QUALITY ASSURANCE

A. Fusion machine technician qualifications: 1-year experience in the installation of similar PE piping systems from the same manufacturer.

B. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

C. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft EPDM gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D 1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D 1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D 2466 or ASTM D 2467.
      c. DWV fittings: In accordance with ASTM D 2665.
   3. Solvent cement: In accordance with ASTM D 2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp Type P70.
         2) Cement: IPS Corp Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC GRAVITY SEWER PIPING

A. Materials:
   1. Polyvinyl chloride (PVC) gravity sewer pipe and fittings: In accordance with ASTM D 3034 for piping NPS 15 and smaller diameter, and to ASTM F 679 for piping NPS 18 and larger diameter:
      a. Referenced standards apply as complemented and modified in this Section.
      b. Fittings: Supplied by the pipe manufacturer.
   2. PVC compounds: Class Number 12454-C, in accordance with ASTM D 1784:
      a. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers: Not to exceed 10 parts by weight per 100 of PVC resin in the compound.
   3. Pipe NPS 15 and smaller diameter: Wall thickness SDR 26:
      a. Joints: Push-on joints in accordance with ASTM D 3212.
   4. Pipe NPS 18 and larger diameter:
      a. PVC compound: Cell classification 12454-C in accordance with ASTM D 1784.
      b. Minimum wall thickness: Thickness T-1 in accordance with Table 1 in ASTM F 679.

c. Joints: Integral bell gasketed joints in accordance with ASTM F 679.
d. Bell: Fabricated from pipe sections, thickness of the wall of the bell equivalent to the pipe wall thickness.
e. Gasket ring: Locked into the bell.
f. Spigot end of the pipe: Marked by the manufacturer to identify the final in-place position of the spigot in the bell.

5. Fittings, including wyes, tees, elbow caps, plug adapters, and manhole waterstops: Same wall thickness as the pipe:
   a. Fittings: Factory molded with joints and gaskets equal to those of the pipe.
6. Gasket: Neoprene in accordance with ASTM D 3212 or ASTM F 477:
   a. Keep rubber gasket in place during pipe joining.
7. Gasket for connection to manhole: Stainless steel clamp with gasket or similar device to seal the penetration.

2.04 PP PIPING

A. Materials:
   1. Pipe: Schedule 40 dimensions, extruded from Type I-19509 material in accordance with ASTM D 4101.
   2. Fittings: Molded from the same material and same laying length in accordance with ASME B 16.12:
      a. Fittings: Manufactured by pipe manufacturer.

2.05 PE TUBING AND FITTINGS

A. Materials:
   1. Small bore PE tubing: Black flexible virgin PE tubing, OD copper tubing size.
      a. Plastic tubing ID as follows:
         1) For NS 1/4 inch, ID of 0.170 inch.
         2) For NS 5/16 inch, ID of 0.187 inch.
         3) For NS 3/8 inch, ID of 0.251 inch.
         4) For NS of 1/2 inch, an ID of 0.375 inch.
   2. Fittings: Compression fittings, Dekoron E-Z; or equal.
   3. Protective sheath:
      a. Manufacturers: One of the following or equal:
         1) Dekoron, "Poly-Cor."
         2) Parker Hannifin Corp./Fluidconnector Products, Parflex Division, Multitube.
   4. Plug-in fittings for connection to instruments: Brass quick-connect fittings.

2.06 POLYETHYLENE PIPING FOR DRAIN, WASTE, AND VENT PIPING SYSTEMS

A. General:
   1. Pipe and fittings: High-density polyethylene.
   2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F 714:
      a. SDR: Maximum of 11.

B. Manufacturers: One of the following or equal:
   1. DuPont, Sclairpipe.
   2. Polaris, Duratuff; or equal.

C. Pipe, fittings, and adapters: Furnished by the same manufacturer, and compatible with components in the same system and with components of other systems to which connected.

D. Materials:
   1. Polyethylene: In accordance with ASTM D 1248, Type III, Class C, Category 5, Grade P34; listed by the Plastic Pipe Institute under the designation PE 3408; and have a minimum cell classification, in accordance with ASTM D 3350.
   2. Pipe and fittings: Manufactured from material with the same cell classification.

2.07 SOURCE QUALITY CONTROL

A. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D 1785.

B. PVC gravity sewer piping:
   1. Mark pipe and fittings in accordance with ASTM D 3034. Also mark the production control code on pipe and fittings.

C. PP piping:
   1. Test samples and testing: Cut test samples of pipe, 6 inches long, from full length sections and test by the method outlined in accordance with ASTM D 2412:
      a. Deflect pipe at least 35 percent without failure. Stiffness at 5 percent deflection equals or exceeds 55 pounds per square inch after the test samples have been immersed in a 5 percent solution by weight of sulfuric acid and n-Heptain for a period of 24 hours prior to testing.
      b. Failure is defined as rupture of the pipe wall.
      c. Stiffness factor may be computed by the method outlined in accordance with ASTM D 2412 or by dividing the load in pounds per linear inch by the deflection in inches and 5 percent deflection.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F 645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
   3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
   4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
   1. Solvent weld joints in accordance with ASTM D 2855:
      a. For PVC pipe in chemical service use IPS Corp. Type 724 cement in accordance with manufacturer's instructions.
   2. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC gravity sewer piping:
   1. Install piping in accordance with manufacturer's published instructions, as modified and complemented in this Section.
   2. Install pipe and fittings not later than 4 months after their manufacture.
   3. Provide for contraction and expansion at joints with a gasket ring.
   4. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
   5. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
   6. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations:
      a. Provide opening for connection large enough to allow subsequent grouting around the manhole gasket.
      b. Grout around the manhole gasket and seal the opening.

D. Installation of PP piping:
   1. Install piping in accordance with manufacturer's published instructions.

E. Installation of polyethylene (PE) tubing and fittings:
   1. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.
   2. Bundle tubing in groups of parallel tubes within protective sheath.
   3. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician's tape.
   4. Grade tubing connected to meters in one direction.

F. Installation of PE piping for drain, waste, and vent:
   1. Install piping as recommended in manufacturer's published instructions.

3.02 FIELD QUALITY CONTROL

A. Leakage test for HDPE piping:
   1. Pressure test with maximum leakage allowance: Perform test prior to backfilling (cover pipe at intervals and/or curves if necessary to hold pipe in place during testing):
      a. Pressure: As specified in Section 15052 or 125 pounds per square inch, gauge.
      b. Test with water as test medium.
      c. Remove all free air from test section and raise pressure at steady rate to test pressure.
      d. Apply and allow initial test pressure to stand without makeup pressure for 3 hours to allow for diametric expansion or pipe stretching to stabilize.
      e. After stabilization period, return to test pressure and hold for 3 hours.
      f. Amount of make up water allowable for expansion during pressure test in accordance with PPI Technical Report TR 31-88.
      g. No visual leaks or pressure drops allowed during final test period.

B. Mandrel tests for PVC gravity sewer and HDPE piping:
   1. Perform initial mandrel test:
      a. After cleaning and completion of other tests.
      b. After placement and compaction of backfill.
      c. Before construction of pavement or surfacing.

d. Not sooner than 30 days after pipe installation.
e. Not later than 60 days after installation.

2. Perform final verification mandrel test:
   a. Not sooner than 30 days before the end of the warranty period.
   b. Not later than 10 days before the end of the warranty period.
   c. Consider the final verification mandrel test a warranty service, and include the costs related to final verification mandrel test in the Contract Price.]
3. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	Mandrel Diameter, inches
6	5.50
8	7.37
10	9.21
12	10.96
15	13.56

4. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
5. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
   a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
Source Testing (Witnessed or Non-witnessed)	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Non-witnessed	Not required		Not required		Not required		Not required	

END OF SECTION

SECTION 15244

POLYVINYL CHLORIDE (PVC) PIPE: AWWA C900 [AND AWWA C905]

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. AWWA C900 and AWWA C905 PVC pipe and fittings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15076 - Pipe Identification.
      e. Section 15120 - Piping Specialties.
      f. Section 15211 - Ductile Iron Pipe: AWWA C151.
      g. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C605 - Standard for Underground Installation of PVC and PVCO Pressure Pipe and Fittings for Water.
   3. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches, for Water Transmission Distribution.
   4. [C905 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In.]
   5. M23 – PVC Pipe – Design and Installation Manual.

B. ASTM International (ASTM):
   1. A 536 - Standard Specification for Ductile Iron Castings.
   2. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D 3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
   4. F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

5. F 645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 ABBREVIATIONS

A. DR: Dimension ratio.

B. NPS: Nominal pipe size followed by the size designation.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Shop Drawings:
   1. Describe materials, pipe, fittings, and gaskets.
   2. Manufacturer's product handling and installation instructions.

C. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756.
   1. Include date of manufacture for each lot delivered.

D. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.05 QUALITY ASSURANCE

A. Pipe in potable water applications: Provide pipe bearing NSF 61 seal.

B. Mark plastic pipe with date of extrusion, nominal size, class, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Deliver, offload, handle, and store pipe in accordance with manufacturer's or pipe supplier's recommendations and best practices provided by AWWA M23 and AWWA C605, including compliance with minimum recommended bending radius and maximum safe pulling forces for each specific pipe.

PART 2 PRODUCTS

2.01 PIPE

A. General:
   1. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   2. In accordance with AWWA C900 and AWWA C905.

3. Made from a PVC compound conforming to cell classification 12454 in accordance with ASTM D 1784.
4. Marked verifying suitability for potable water service in accordance with NSF 61.

B. Pipe:
1. Bell and spigot:
a. Pipe with integral bell.
b. Pressure Class as scheduled in Section 15052 with a minimum DR of ___.
c. Manufacturers:
1) Diamond Plastics Corporation.
2) CertainTeed.
3) North American Pipe Corporation.

2.02 FITTINGS

A. Material:
1. Cast or ductile iron fittings as specified in Section 15211, sized for the dimensions of the pipe being used.

B. Equal to or greater pressure rating than the pipe.

2.03 JOINTS

A. Bell and spigot joints:
1. Push-on or mechanical joint type as identified in the Piping Schedule in Section 15052.
2. Gasketed joint assembly: Meet or exceed the requirements in accordance with ASTM D 3139.
3. Factory installed gaskets: EPDM in accordance with ASTM F 477.
4. Joint restraint at fittings:
a. Concrete thrust blocks:
1) Install thrust blocks at all changes in pipe diameter and at all fittings.
2) Design thrust blocks for both test and peak operating pressures.
b. Mechanical wedge action joint restraints:
1) Manufacturers: One of the following or approved equal:
a) EBAA Iron, Inc.:
(1) For pipes 3 to 36-inch: Series 2000PV.
(2) For pipes 42 and 48-inch: Series 2200.
b) Star Pipe Products, Series 4000.
2) Materials:
a) Gland body: Ductile iron in accordance with ASTM A 536.
b) Wedge and wedge actuating components: Ductile iron in accordance with ASTM A 536.
(1) Wedges: Heat-treated to a minimum of 370 BHN.
c) Actuating bolts and nuts: Ductile iron in accordance with ASTM A 536.
(1) Provide torque-limiting twist off components to ensure proper installation.
3) Coatings:
a) Provide a manufacturer applied coating system.

b) Manufacturers: One of the following or equal:
(1) EBAA Iron Inc., Mega-Bond.
(2) Star Pipe Products, Star-Bond.
4) Consist of multiple gripping wedges incorporated into a follower gland meeting the requirements in accordance with AWWA C111.
5) Allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
6) Pressure rating equal to or greater than that of the pipe on which it is being used and a minimum safety factor of 2:1 for all sizes.]

c. [Push-on joint restraint harnesses:
1) Manufacturers: One of the following or approved equal:
a) EBAA Iron, Inc.:
(1) For pipes 4 to 12-inch: Series 1500.
(2) For pipes 14 to 48-inch: Series 2800.
b) Star Pipe Products, Series 4100P.
2) Materials:
a) Restraint and backup rings: Ductile iron in accordance with ASTM A 536.
b) Wedge and wedge actuating components: Ductile iron in accordance with ASTM A 536.
c) Tie rods: Low alloy steel in accordance with AWWA C111.
3) Coatings:
a) Provide manufacturer applied coating system.
b) Manufacturers: One of the following or equal:
(1) EBAA Iron Inc., Mega-Bond.
(2) Star Pipe Products, Star-Bond.
4) Consist of a backup ring behind the PVC bell and a restraint ring consisting of multiple gripping wedges connected with number and type of tie rods as recommended by the manufacturer.
5) Allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the push-on joint.
6) Pressure rating equal to or greater than that of the pipe on which it is being used and a minimum safety factor of 2:1 for all sizes.

2.04 SOURCE QUALITY CONTROL

A. Bell and spigot piping:
1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, 2 times the pressure class of the pipe for a minimum of 5 seconds.
2. Hydrostatic proof testing in accordance with AWWA C905: Test pipe and integral bell to withstand, without failure, 2 times the pressure class of the pipe for a minimum of 5 seconds.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install piping in accordance with ASTM F 645, AWWA C605, the Appendix of AWWA C900 and AWWA C905 and manufacturer's or pipe supplier's published installation instructions.
2. For open cut installations, install underground warning tape as specified in Section 15076.
3. Install pipe with tracer wire as specified in Section 15076.
   a.

B. Tapping:
   1. Direct tapping:
      a. Direct taps are allowed for AWWA C900 Class 235 and Class 305 pipe, NPS 6-inch through 12-inch only.
      b. 1-inch is the maximum allowable outlet size for performing a direct tap.
   2. Saddle tapping:
      a. Saddle taps are allowable on all sizes and classes of AWWA C900 pipe.
      b. 2-inch is the maximum allowable outlet size for performing a saddle tap.
      c. As specified in Section 15120 for allowable service saddles.
   3. Tapping sleeves:
      a. Tapping sleeves are allowable on all sizes and classes of PVC AWWA C900.
      b. As specified in Section 15120 for allowable tapping sleeves.

3.02 FIELD QUALITY CONTROL

A. Leakage test for piping:

1. Subject to visible leak test and pressure test with maximum leakage allowance, as specified in Section 15956.
2. Pressure test with maximum leakage allowance.
   a. Perform test after placing sufficient backfill.
   b. In areas requiring immediate backfill, test prior to placement of permanent surfacing.
   c. Test pressure: As specified in the Piping Schedule in Section 15052.
   d. Maximum leakage allowance for bell and spigot pipe is as follows, where the value for leakage is in gallons per 50 joints per hour.

Test Pressure (psi)	Nominal Pipe Size (inches)									
	4	6	8	10	12	14	16	18	20	24
50	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.96	1.15
75	0.23	0.35	0.47	0.59	0.70	0.82	0.94	1.05	1.17	1.40
100	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	1.35	1.62
125	0.3	0.45	0.6	0.76	0.91	1.06	1.21	1.36	1.51	1.81
150	0.33	0.50	0.66	0.83	0.99	1.16	1.32	1.49	1.66	1.99
175	0.36	0.54	0.72	0.89	1.07	1.25	1.43	1.61	1.79	2.15
200	0.38	0.57	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.29
225	0.41	0.61	0.81	1.01	1.22	1.42	1.62	1.82	2.03	2.43
250	0.43	0.64	0.85	1.07	1.28	1.50	1.71	1.92	2.14	2.56
275	0.45	0.67	0.90	1.12	1.34	1.57	1.79	2.02	2.24	2.69

300	0.47	0.70	0.94	1.17	1.40	1.64	1.87	2.11	2.34	2.81

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
Source Testing (Witnessed or Non-witnessed)	**Training Requirements**		**Installation Testing**		**Functional Testing**		**Process Operational Period**	
	Maintenance (hrs per session)	**Operation (hrs per session)**	**Trips**	**Days (each trip)**	**Trips**	**Days (each trip)**	**Trips**	**Days (each trip)**
Non-witnessed	Not required		Not required		Not required		Not required	

END OF SECTION

SECTION 15259

CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE: ASTM F 441

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: ASTM F 441 CPVC pipe and fittings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 15052 - Common Work Results for General Piping.
      d. Section 15956 - Piping Systems Testing.

1.02 REFERENCES

A. American Water Works Association (AWWA).

B. ASTM International (ASTM):
   1. D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   2. F 438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
   3. F 439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
   4. F 441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
   5. F 493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
   6. F 645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

C. NSF International (NSF).

1.03 ABBREVIATIONS

A. CPVC: Chlorinated polyvinyl chloride.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.

C. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756. Include:
   1. Date of manufacture of pipe for each lot delivered.
   2. Solvent cement manufacturer's report and certification.

D. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.05 QUALITY ASSURANCE

A. Pipe in potable water applications: Provide pipe bearing NSF seal.

B. Mark pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Pipe:
   1. In accordance with ASTM F 441 and Appendix, CPVC 4120.
   2. Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D 1784.
   3. Schedule 80, unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052.
   4. Manufacturers: One of the following or equal:
      a. Charlotte Pipe and Foundry Company.
      b. Eslon Thermoplastics, Inc.
      c. GF Harvel.
      d. Spears Manufacturing Company.
      e. Chemtrol.

C. Fittings:

1. In accordance with ASTM F 438 or ASTM F 439 for pressure fittings, as appropriate to the service and pressure requirement.
2. Same material as the pipe and of equal or greater pressure rating.
3. Supplied by pipe manufacturer.

D. Solvent cement:
1. In accordance with ASTM F 493.
2. Manufacturers: The following or equal:
a. IPS Corporation.
3. Certified by the manufacturer for the service of the pipe.
4. Primer: As recommended by the solvent cement manufacturer.

E. Unions 2-1/2 inches and smaller:
1. Socket end screwed unions.

F. Unions 3 inches and larger:
1. Socket flanges with 1/8-inch full-face soft EPDM gasket.

2.02 SOURCE QUALITY CONTROL

A. Mark pipe and fittings in accordance with ASTM F 441.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Install piping in accordance with ASTM F 645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe.
a. Do not thread pipe.
3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of piping:
1. Clean dirt and moisture from pipe and fittings.
2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file.
a. Remove burrs.
3. Use solvent cement and primer formulated for CPVC.
4. Use primer on pressure and non-pressure joints.
5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

3.02 FIELD QUALITY CONTROL

A. Test as specified in Section 15052 and Section 15956.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
Source Testing (Witnessed or Non-witnessed)	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Non-witnessed	Not required		Not required		Not required		Not required	

END OF SECTION

SECTION 15281

COPPER WATER TUBE: SEAMLESS, ASTM B 88

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Copper water tube-seamless, ASTM B 88.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Commissioning and Process Start-Up.
      c. Section 15061 - Pipe Supports.
      d. Section 15062 - Preformed Channel Pipe Support System.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B 32 - Standard Specification for Solder Metal.
   2. B 88 - Standard Specification for Seamless Copper Water Tube.
   3. B 813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
   4. B 828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.

B. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe and Fittings.

1.03 SUBMITTALS

A. Submit as specified in Section 01330.

B. Shop Drawings.

C. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756.

D. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756.

PART 2 PRODUCTS

2.01 MATERIALS

A. Seamless copper water tube:
   1. Type: ASTM B 88:
      a. Exposed copper piping or tubing: Type L hard-drawn, rigid.
      b. Copper tubing buried in the ground or in plastic conduit: Type K soft-annealed.
   2. Fittings: Manufacturers: Solder type forged, or wrought copper. One of the following or equal:
      a. Hoke, Gyrolok.
      b. Crawford Fitting Company, Swagelok.
      c. Parker.
   3. Solder: ASTM B 32, Alloy Grade Sb5.
   4. Flux: ASTM B 813.
   5. Dielectric insulating unions or fittings: Manufacturers: One of the following or equal:
      a. Mueller Company.
      b. Watts Series 3001A.
   6. Special thread to tube adapters: Manufacturers: One of the following or equal:
      a. Crawford Fitting Company, Swagelok.
      b. Hoke, Gyrolok.
      c. Parker.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Support copper piping and tubing as specified in Sections 15061 and 15062.
   2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
   3. Install copper pipe in accordance with IAPMO IS 3.

B. Installation of copper piping:
   1. Connect copper pipe connected to ferrous pipe or valves, or other non-copper items, by means of dielectric insulating unions or fittings.
   2. Where connections are made to meters or other devices having iron pipe size threaded fittings, provide special thread to tube adapters.

C. Installation of copper tubing:
   1. Install copper tubing in accordance with ASTM B 828 and IAPMO IS 3.
   2. Install copper tubing in straight runs, supported at intervals close enough to avoid sagging.
   3. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
      a. Provide a sizing tool to correct distortions.
   4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
   5. Perform flaring with a flare block and yoke type screw feed flaring tool:

a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
b. Where there are imperfections, cut off the imperfect flare, and prepare a new flare.

3.02 FIELD QUALITY CONTROL

A. Testing: Test copper lines in the same manner as the piping system to which they connect.

3.03 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer services:
1. Provide Manufacturer's Certificate of Source Testing.
2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

			Manufacturer Rep Onsite					
Source Testing (Witnessed or Non-witnessed)	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Non-witnessed	Not required		Not required		Not required		Not required	

END OF SECTION

SECTION 15283

COPPER PIPE, ASTM B 302

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Copper pipe, ASTM B 302.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 15061 - Pipe Supports.
      b. Section 15062 - Preformed Channel Pipe Support System.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B 302 - Standard Specification for Threadless Copper Pipe, Standard Sizes.

B. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe, and Fittings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Copper pipe:
   1. Type: ASTM B 302.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Support copper piping as specified in Sections 15061 and 15062.
   2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
   3. Install copper pipe in accordance with IAPMO IS 3.

B. Installation of copper piping:
   1. Connect copper pipe connected to ferrous pipe or valves, or other non-copper items, by means of dielectric insulating unions or fittings.
   2. Where connections are made to meters or other devices having iron pipe size threaded fittings, provide special thread to tube adapters.

C. Provide air relief valves at high points in the lines.

3.02 FIELD QUALITY CONTROL

A. Testing: Test copper lines in the same manner as the piping system to which they connect.

END OF SECTION

SECTION 15286

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Stainless steel piping and tubing.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
      a. Section 15052 - Common Work Results for General Piping.
      b. Section 15121 - Pipe Couplings and External Joint Restraints.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
   2. B16.11 - Forged Fittings, Socket-Welded and Threaded.
   3. B31.3 - Process Piping.
   4. B36.19 - Stainless Steel Pipe.

B. American Welding Society (AWS):
   1. D1.6 - Structural Welding Code - Stainless Steel.

C. ASTM International (ASTM):
   1. A 182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   2. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A 194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A 269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A 312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.

8. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
9. A 403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
10. A 774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
11. A 778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
12. A 789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
13. A 790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
14. A 928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
15. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
16. B 622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.

D. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 DESIGN REQUIREMENTS

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
2. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
1. Field welding is prohibited.

1.04 SUBMITTALS

A. Layout drawings: Detailed layout drawings showing dimensions and alignment of pipes; location of valves, fittings, and appurtenances; location of field joints; location of pipe hangars and supports; connections to equipment or structures; location and details of shop welds; and thickness and dimensions of fittings and gaskets.
1. Prepare layout drawings.

B. Product data:
1. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
2. Material specifications for pipe, gaskets, fittings, and couplings.
3. Data on joint types and components used in the system including flanged joints, grooved joint couplings and screwed joints.

C. Manufacturing certifications.

D. Welder and weld operator qualification certificates and welding procedures.

PART 2 PRODUCTS

2.01 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. Piping less than 3 inches in nominal diameter:
      a. Minimum wall thickness corresponding to Schedule 40S.
   2. Piping with threaded or grooved joints:
      a. For general service applications with pressures less than 250 pounds per square inch gauge, minimum wall thickness corresponding to Schedule 40S.
      b. For pressures exceeding 250 pounds per square inch gauge, minimum wall thickness corresponding to Schedule 80S.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A 240	In accordance with ASTM A 778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A 240	In accordance with ASTM A 312

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A 240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A 774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
   1. Material: In accordance with ASTM A 240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A 403, Class WP.

3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
4. End configuration: As needed to comply with specified type of joint.
5. Forgings in accordance with ASTM A 182, or barstock in accordance with ASTM A 276. Match forging or barstock material to the piping materials.

F. Piping joints:
1. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, or screwed with Teflon tape thread lubricant, as scheduled
2. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.
3. Flanges for Schedule 40S and Schedule 80S pipe:
   a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150 .
   b. Material: In accordance with ASTM A 182.
4. Grooved joints:
   a. Pressure less than 500 pounds per square inch:
      1) Cut grooves from Schedule 40 or higher.
   b. Heavier schedule pipe sections used for cut groove ends:
      1) Tapered inside diameter to transition from the inside diameter of the lighter schedule pipe.
   c. Butt welds connecting pipes of different schedules that leave an abrupt change in inside diameter are not allowed.
   d. Couplings:
      1) Rigid type, cast from ductile iron, Victaulic Style 07 or equal. High performance coating as specified in Section 09960.
      2) Type 316 Grade CF-8M stainless steel in accordance with ASTM A 351, A 743, and A 744.
         a) Bolts: Stainless steel in accordance with ASTM F 593, Group 2, Condition CW.
         b) Nuts: Stainless steel.
         c) Manufacturers: The following or equal:
            (1) Piedmont Pacific Corporation.
            (2) Victaulic Style 489 Rigid Coupling.

G. Gaskets:
1. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.
   a. Drinking water applications: NSF Standard 61 compliant materials only.

H. Bolts for flanges **:**
1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A 193 heavy hex head.
   a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
   b. Nuts: In accordance with ASTM A 194 heavy hex pattern.

I. Fabrication of pipe sections:
1. Welding: Weld in accordance with ASME B31.3.
2. Weld seams:
   a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.

b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:
1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A 380 or A 967.
a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
b. Passivation treatments with citric acid are not allowed.
3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

2.02 STAINLESS STEEL TUBING

A. Stainless steel tubing:
1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A 269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
1. Components made of:
a. Type 316 stainless steel.
2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
3. Flare type fittings are not acceptable.
4. Manufacturers: One of the following or equal:
a. Crawford Fitting Company, Swagelok.
b. Hoke, Gyrolok.
c. Parker, CPI.

C. Valves for use with stainless steel tubing:
1. Ball type valves with swage ends to match tubing diameter.
2. Constructed from:
a. Type 316 stainless steel with TFE seats.
3. Manufacturers: The following or equal:
a. Crawford Fitting Company, Swagelok.

2.03 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A 778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A 774.
   1. Supplementary testing is not required.

D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

F. Shipment to site:
   1. Protect all flanges and pipe ends by encapsulating in dense foam.
   2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
   3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
   4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
   5. Notify ENGINEER when deliveries arrive so ENGINEER may inspect the shipping conditions.
   6. ENGINEER may reject material due to improper shipping methods or damage during shipment.

PART 3 EXECUTION

3.01 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 15052.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.03 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 15430

EMERGENCY EYE/FACE WASH AND SHOWER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Emergency shower and eyewash.

B. Related section:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01756 - Commissioning and Process Start-Up.
      b. Section 15050 - Common Work Results for Mechanical Equipment.
      c. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. Z358.1 - Emergency Eyewash and Shower Equipment.
   2. Z535.1 - Safety Color.

B. American Society of Mechanical Engineers (ASME).

C. National Electrical Manufacturers Association (NEMA).

D. National Fire Protection Association (NFPA).

E. Occupational Safety and Health Administration (OSHA).] [California Department of Occupational Safety and Health Administration (Cal-OSHA).

F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756.

B. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756.

C. Shop drawings.

D. Product Data:

1. Submit manufacturer's product literature information for products specified.
2. Manufacturer's Installation Instructions.

E. Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Show evidence that the firm has been engaged in producing such materials and products for at least 5 years and that the product submitted has a satisfactory performance record of at least 5 years.

B. Installer qualifications: Installer shall have 3 years experience in installing these materials for similar projects and shall be approved by the manufacturer prior to bidding of the project.

C. Regulatory requirements:
1. As applicable, equipment of this Section shall comply with requirements of public agencies of the state where the project is located including ASME Cal-OSHA NFPA OSHA UL.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver to the job site in manufacturer's original containers.

B. Delivery: After wet operations in building are completed.

C. Storage and protection:
1. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.
2. Keep materials dry until ready for use.
3. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.
4. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS

2.01 EMERGENCY EYE/FACE WASHES

A. General design requirements:
1. Portable sterile emergency eyewash station:
2. Manufactures: The following or equal:
   a. Haws Model 7601.37
3. General requirements:
   a. Provide complete portable sterile emergency eyewash station complete with eyewash station, body spray, mounting hardware, sterile solution cartridge, and installation manual.
   b. Design and installation shall meet requirements of ANSI Z358.1
   c. Tank construction shall be stainless steel.
   d. All materials shall be corrosion resistant for installation inside a sodium hypochlorite generation building.
4. Spare equipment:

a. Provide spare cartridges of sterile solution for 12 months of operation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturers' recommendations.

B. Install fixed equipment in accordance with manufacturer's instructions.

C. Plumbing and mechanical work as specified in Section 15050.

D. Electrical connections and distribution as specified in Section 16050.

3.02 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturers services from each Manufacturer
1. Provide Manufacturer's Certificate of Source Testing.
2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
3. On site services.

Manufacturer Rep Onsite							
Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
4	2	1	2	1	1	Not required	

END OF SECTION

SECTION 15740

HEAT PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wall mounted heat pumps.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 01614 - Wind Design Criteria.
      e. Section 15050 - Common Work Results for Mechanical Equipment.
      f. Section 15082 - Piping Insulation.
      g. Section 15841 - Air Terminal Units.
      h. Section 15936 - Instrumentation and Control Devices for HVAC.
      i. Section 15954 - Testing, Adjusting, and Balancing for HVAC.
      j. Section 16050 - Common Work Results for Electrical.
      k. Section 16060 - Grounding and Bonding.
      l. Section 16075 - Identification for Electrical Systems.
      m. Section 16123 - 600-Volt or Less Wires and Cables.
      n. Section 16130 - Conduits.
      o. Section 16134 - Boxes.
      p. Section 16140 - Wiring Devices.
      q. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      r. Section 16411 - Disconnect Switches.

1.02 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 210-240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
   2. 270 - Sound Rating of Outdoor Unitary Equipment.

B. Air Movement and Control Association International, Inc. (AMCA):
   1. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   1. 15 - Safety Standard for Refrigeration Systems.
   2. 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   3. 62.1 - Ventilation for Acceptable Indoor Air Quality.

D. Federal Specification (FS):
   1. Standard 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.

E. National Electrical Code (NEC).

F. National Electrical Manufacturers Association (NEMA):
   1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

G. National Fire Protection Association (NFPA):
   1. 54 - National Fuel Gas Code.
   2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

H. National Roofing Contractors Association (NRCA).

I. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. NEMA:
   1. Type 1 enclosure in accordance with NEMA 250.
   2. Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Seismic supports: Design supports to comply with the criteria specified in Section 01612.
   2. Wind supports: Design supports to comply with the criteria specified in Section 01614.
   3. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
   4. Water piping, drains, and venting: In accordance with building code, mechanical code, and plumbing code as specified in Section 01410 and in accordance with NFPA 90A.
   5. Fans supplied with heat pump units: Rated in accordance with AMCA 210.
   6. Unit heat pumps: Rated in accordance with AHRI Standards 210-240 and AHRI 270 and in accordance with the latest version of ASHRAE 15.
   7. Roof curbs: Designed in accordance with NRCA standards.
   8. Insulation and adhesives: In accordance with NFPA 90A requirements for flame spread and smoke generation.
   9. Refrigerant: HCFC R-410A**.**

B. Performance requirements:
   1. Performance requirements as specified and as scheduled on the Heat Pump Schedule in this Section.
   2. Maximum sound power levels in the 8 octave band ranges, measured in accordance with AHRI Standard 270:

OCTAVE BANDS								
Unit Nominal Capacity (Tons)	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
0 to 5	64	70	71	74	74	7871	67	67
7-1/2 to 10	65	70	73	80	84	78	73	65
12 and larger	84	88	84	83	84	78	72	68

   3. Capable of starting and providing cooling from 45 to 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI Standard 210-240.
   4. Capable of starting and providing heating at or above 0 degrees Fahrenheit outdoor ambient air temperature.
   5. Minimum cooling and heating capacities, energy efficiency ratios (EER), and coefficient of performance (COP), as rated in accordance with AHRI 210-240 and 270:

				Heating High Temperature(1)		**Heating Low Temperature(2)**	
Nominal Capacity (Tons)	**Standard cfm**	**Cooling Capacity (Btuh)**	**EER(3)**	**Capacity (Btuh)**	**COP**	**Capacity (Btuh)**	**COP**
3	1,200	36,400	9	35,200	3.0	18,400	2.0
4	1,750	47,000	9	47,000	3.0	26,400	2.0
5	2,000	59,000	9	59,000	3.0	26,400	2.1
6	2,400	72,800	11.0	70,400	3.0	36.800	2.0
7-1/2	3,000	87,000	11.0	89,000	3.0	49,000	2.0
10	4,000	113,000	11.0	116,000	3.0	65,000	2.0

				Heating High Temperature[1]		Heating Low Temperature[2]	
Nominal Capacity (Tons)	**Standard cfm**	**Cooling Capacity (Btuh)**	**EER[3]**	**Capacity (Btuh)**	**COP**	**Capacity (Btuh)**	**COP**

Notes:

(1) high temperature heating standard:
   a. 70 degrees Fahrenheit dB indoor entering air temperature.
   b. 47 degrees Fahrenheit dB, 43 degrees Fahrenheit wet bulb outdoor entering air temperature.
(2) Low temperature heating standard:
   a. 70 degrees Fahrenheit dB indoor entering air temperature.
   b. 17 degrees Fahrenheit dB, 15 degrees Fahrenheit wet bulb outdoor entering air temperature.
(3) EER value:
   a. Deduct 0.2 from the required EER's for units with a heating section other than electric resistance heat.
   b. EER value based on California Title 24 requirements.

6. Unit air flows for cooling, unless scheduled otherwise:
   a. Minimum: 300 cubic feet per minute per ton of cooling.
   b. Maximum: 500 cubic feet per minute per ton of cooling.
7. Air filters: 25 to 30 percent efficiency when rated in accordance with ASHRAE Tested Standard 52.2.

C. Electrical and control system design:
1. Design and supply necessary electrical power and control systems, thermostats, components, and wiring to make a complete functioning system. Comply with referenced electrical Sections and design to perform the system cooling only or cooling/heating requirements as specified in Section 15936.
2. Electrical power and control systems: As specified in the following sections:
   a. Section 16050.
   b. Section 16060.
   c. Section 16075.
   d. Section 16123.
   e. Section 16130.
   f. Section 16134.
   g. Section 16140.
   h. Section 16411.

1.05 SUBMITTALS

A. Shop drawings:
1. System layout, mechanical, electrical power, and control diagrams.
2. Materials.
3. Supports and seismic bracing calculations and details.
4. Cut sheets on primary and ancillary equipment.
5. Proposed cutting and patching.
6. Noise levels in 8 octave bands showing compliance with specified levels.
7. Factory test results.

B. Operation and Maintenance Data.

C. Warranties.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in 1 piece, factory assembled, piped, internally wired, charged with refrigerant and compressor oil, and tested.

B. Protect equipment from dust and atmospheric exposure:
   1. Provide temporary closures for equipment openings designed for airflow.

1.07 SITE CONDITIONS

A. As specified in Section 01610.

1.08 WARRANTY

A. Special warranties: From the date of Acceptance of the project or date of beneficial use:
   1. 1-year warranty on all components.
   2. 5 years: For refrigerant compressors and closed or sealed refrigerant systems.
   3. 5 years: For electric heaters (if supplied).
   4. 5 years: For evaporator and condensing coils.

1.09 MAINTENANCE

A. Extra materials: Provide 2 extra sets of filters per unit installed.

PART 2 PRODUCTS

2.01 WALL MOUNTED HEAT PUMPS

A. Manufacturers: One of the following or equal:
   1. Bard, Model W__H.
   2. Marvair, similar models.

B. Compressors:
   1. Fully hermetically sealed, high efficiency, reciprocating or rotary or scroll type, with rubber grommet vibration isolation.

C. Fans:
   1. Indoor air fan:
      a. Direct driven with capacitor start motor; fan centrifugal type, steel with corrosion resistant finish, statically and dynamically balanced.
      b. Bearings: Permanently sealed ball bearing type and permanently lubricated.
   2. Outdoor condenser fan:
      a. Propeller type, direct drive, aluminum blades, dynamically balanced.
      b. Bearings: Permanently sealed ball bearing type and permanently lubricated.

D. Coils:
   1. Evaporator and condenser coils: Seamless copper tubes with mechanically bonded aluminum plate fins.

E. Refrigerant components: Refrigerant circuit including:
   1. Accumulator and filter/drier.
   2. Expansion device.
   3. Flow control valves.
   4. Reversing valve.
   5. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.

F. Controls and equipment safety features:
   1. Provide system controls for a complete functioning system:
      a. High and low evaporator fan speed control for cooling and heating modes.
      b. Fan only operation.
      c. Ventilation control; open (exhaust) or closed.
      d. Space temperature condition setting.
      e. Thermostat to cycle unit to maintain space condition; provide change over thermostat for heat pumps.
      f. Automatic switch to auxiliary electric heat as required.
   2. Equipment safety features:
      a. Thermostatic basepan drain to prevent freeze up of the fan in collected condensate.

G. Electrical:
   1. Provide for single external power connection of voltage and phases as scheduled; control power wiring internal to the unit.

H. Unit casing:
   1. Weatherproof design, reinforced and braced for maximum rigidity.
   2. Provided with:
      a. Filter rack for filters accessible through the front of the unit.
      b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
      c. Horizontal drain connection.
      d. Knockouts for power connections.
      e. Provide supply and return grilles.

I. Auxiliary electrical resistance heaters:
   1. Size as specified on Heat Pump Schedule.
   2. Open wire nichrome elements.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Ascertain structural sufficiency to support installation.

3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required.
    a. Submit details of proposed cutting and patching.
4. Confirm specified thermostat or other controls are compatible with specified equipment.

B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.

3.02 PREPARATION

A. Before installation remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings.

3.03 INSTALLATION

A. Comply with applicable installation requirements as specified in Section 15050.

B. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

C. Install and wire unit air conditioners, controls, and thermostats in accordance with manufacturer's recommendations.

D. Provide flexible duct and flexible piping connections as indicated on the Drawings at connections to unit air conditioners.

E. Provide venting in accordance with building code, mechanical code, and plumbing code as specified in Section 01410, and in accordance with NFPA 54.

F. Upon completion of installation, remove debris from ductwork and equipment and clean ducts.

3.04 FACTORY QUALITY CONTROL

A. Factory test in cooling and heating modes including economizer operation. Evacuate coils and refrigerant system for 30 minutes prior to final charging of unit before shipment.

3.05 FIELD QUALITY CONTROL

A. Test equipment and installation to verify tightness, operation, and unit heat pump vibration is within manufacturer's submitted maximum.

B. Test equipment performance and balance equipment as specified in Section 15954.

3.06 SCHEDULES

A. Heat Pump Schedule.

Equip. No.	Location	Cooling				Mechanical Heating				Aux. Heat kW	Unit Power			Air Fan		OSA (cfm)	Additional Requirements (see Notes at End of Schedule)
		Net Total/ Sensible (MBH)	Evaporator		Condenser Inlet DB (°F)	Total Capacity Minimum MBH	Condenser		Evaporator Inlet DB (°F)		V	Ph.	MCA / MOPAmp	cfm	ESP "WC		
			Inlet DB/WB (°F)	Outlet DB/WB (°F)			Inlet DB (°F)	Outlet DB (°F)									
HPU-1	Sodium Hypo Elec Room	37.4 / 37.4	76/44	60/38	105	14.8	64	71	15	9	480	3	28 / 30	1900	0.2	20	1, 3, 4, 8, 9, 15
HPU-2	Well Site 1	24.6 / 24.6	76/44	60/38	105	15.4	64	71	15	9	460	3	25 / 25	1270	0.2	20	1, 3, 4, 8, 9, 15
HPU-3	Well Site 2	24.6 / 24.6	76/44	60/38	105	15.4	64	71	15	9	460	3	25 / 25	1270	0.2	20	1, 3, 4, 8, 9, 15

Additional Requirement Notes:

1. Wall mounted.
2. Base/floor mounted.
3. Side return connection.
4. Side supply discharge connection.
5. Bottom return connection.
6. Bottom supply discharge connection.
7. Thermostat provided by Contractor.
8. Thermostat provided by manufacturer.
9. 24-volt control voltage.
10. 120-volt control voltage.
11. Natural gas fired.
12. Liquefied petroleum gas fired.
13. Indoor blower fan direct drive.
14. Indoor blower fan belt drive.
15. Include auxiliary electric heater (Power Included in Unit Power).

END OF SECTION

SECTION 15762

HEATING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electric unit heaters (EUH).

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01410 - Regulatory Requirements.
      b. Section 01610 - Project Design Criteria.
      c. Section 01612 - Seismic Design Criteria.
      d. Section 01614 - Wind Design Criteria.
      e. Section 15050 - Common Work Results for Mechanical Equipment.
      f. Section 15936 - Instrumentation and Control Devices for HVAC.
      g. Section 15954 - Testing, Adjusting, and Balancing for HVAC.
      h. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA):
   1. 302 - Application of Sone Ratings for Non-Ducted Air Moving Devices.

B. American Gas Association (AGA).

C. National Electrical Code (NEC).

D. National Fire Protection Association (NFPA):
   1. 54 - National Fuel Gas Code.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (100 V Maximum).

F. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. NEMA Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Provide seismic and wind supports meeting the seismic design criteria as specified in Section 01612 and wind design criteria for exterior units as specified in Section 01614.
   2. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
   3. Hot water piping, gas piping, drains, venting, and other appurtenances of unit heaters: Install in accordance with building code, mechanical code, and plumbing code as specified in Section 01410, and the NFPA.
   4. Noise levels for unit heaters installed in offices, hallways, or entry areas: Not to exceed 10 Sones as measured in accordance with AMCA Publication 302.
   5. Motors supplied with heating units: As specified in Section 16222.

B. Performance requirements are included in the Heating Unit Schedules at the end of this Section.

C. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system.
   1. Comply with referenced electrical Sections and design to perform system heating functions as specified in Section 15936.

1.05 SUBMITTALS

A. Shop drawings:
   1. System layout, mechanical, electrical power, and control diagrams.
   2. Materials.
   3. Supports and seismic bracing calculations and details.
   4. Cut sheets on primary and ancillary equipment.
   5. Sound ratings of fans in Sones in accordance with AMCA Publication 302.

B. Samples: Manufacturer's standard color chips for cabinets finish.

C. Certificates: Successful testing of burners used in gas unit heaters.

D. Operation and Maintenance Data.

E. Warranties.

1.06 QUALITY ASSURANCE

A. Provide heating units and controls that are listed by UL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.
   1. Provide temporary closures for equipment openings designed for airflow.

1.08 SITE CONDITIONS

A. As specified in Section 01610.

1.09 WARRANTY

A. Provide a warranty to be in force and effect for a period of 1 year from the date of final acceptance by the Owner.

PART 2 PRODUCTS

2.01 ELECTRIC UNIT HEATERS (EUH)

A. Manufacturers: One of the following or equal.
   1. Trane, Type UHEC.
   2. Markel, Series 5100.
   3. Chromalox, Type LUH or VUH.

B. Fan type: Aluminum axial flow:
   1. Provide fan guards.
   2. Dynamically balance.
   3. Fan designed for quiet operation.
   4. Permanently lubricated ball bearings.
   5. Automatic reset thermal overload protection.

C. Heating element characteristics:
   1. Rated capacity at entering air temperature of 65 degrees Fahrenheit.
   2. Fin type, steel plated heater elements, with elements brazed to common fins, designed for maximum strength and maximum heat transfer.
   3. 3-phase designed for balanced phases.
   4. Over temperature cutout with automatic reset.

D. Features:
   1. Built-in magnetic contactors.
   2. Control transformer for 24 or 120-volt control as indicated in the Heating Unit Schedules.
   3. Required mounting brackets.
   4. Individually adjustable outlet louvers.
   5. Cabinet formed of minimum thickness 18-gauge steel with steel stiffeners.
   6. Controls:
      a. Provide thermostat as specified in this Section.
      b. Provide control transformer suitable for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.

E. Finishes:
   1. Casing finish backed enamel in manufacturer's standard color.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Verify structural sufficiency to support installation.

3. Verify that chassis, shafts, and openings are correctly located.
    a. Otherwise cut new openings where required.
4. Confirm specified thermostat and other controls are compatible with specified equipment.

B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine possible conflicts in dimensions and clearances.

3.02 PREPARATION

A. Before installation, remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings with tape or plastic.

3.03 INSTALLATION

A. Anchoring and support: Install anchoring for seismic and wind forces to meet the design criteria specified in Sections 01612 and 01614.

B. Alignment: Adjust ductwork alignment when necessary to resolve conflicts with architectural and structural features or to resolve conflicts with work of other trades.

C. Install and wire unit heaters and thermostats in accordance with manufacturer's recommendations.
1. Provide disconnect switches at the unit heaters wherever indicated on the Drawings, specified in this Section, scheduled and wherever required by code.

D. Adjust heater units with louvers for optimum air circulation.

E. Provide gas unit heater venting in accordance with mechanical code and plumbing code as specified in Section 01410 and in accordance with NFPA 54.

3.04 FIELD QUALITY CONTROL

A. Test equipment and installation to verify operation is within manufacturer's standards and that noise levels do not exceed levels specified.

B. Test equipment performance and balance equipment as specified in Section 15954.

3.05 HEATING UNIT SCHEDULES

A. Electric Heating Unit Schedule.

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ELECTRIC HEATING UNIT SCHEDULE						
		Capacity		Fan		
Equip. No.	Location	Input kW / V / Ph.	Output MBH	cfm	Hp	Additional Requirements (see Schedule Notes)
EUH-1	NaOH room	5 / 480 / 3	17.0	380	1/35	3, 5, 7, 8, 11, 13

HEATING UNIT SCHEDULE NOTES	
1. Steam service	14. Fan belt drive.
2 Hot water service.	15. Unit located inside building (indoors).
3. Electric service.	16. Unit located on roof or building exterior.
4. Thermostat provided by Contractor.	17. Natural gas fired.
5. Thermostat provided by heater manufacturer.	18. Liquefied petroleum gas fired.
6. Horizontal mounting.	19. Unit flange mounted.
7. Vertical mounting.	20. Unit slip-in mounted.
8. Wall mounting.	21. Provide stainless steel UH exchanger.
9. Floor mounting.	22. Provide stainless steel UH gas burner.
10. Recessed mounting.	23. Side air intake to fan.
11. 24-volt control voltage.	24. Side air discharge.
12. 120-volt control voltage.	25. Down air discharge from unit.
13. Fan direct drive.	26. Down air inlet.
	27. Provide unit suitable for NEC Group D, Class I, Division 1 hazardous location.

END OF SECTION

SECTION 15830

FANS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fans, including:
   1. Type 14 - Centrifugal sidewall exhaust fans.
   2. Fan variable speed controller.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 01614 - Wind Design Criteria.
      d. Section 01756 - Commissioning and Process Start-Up.
      e. Section 01782 - Operation and Maintenance Data.
      f. Section 09960 - High-Performance Coatings.
      g. Section 15050 - Common Work Results for Mechanical Equipment.
      h. Section 15852 - Louvers.
      i. Section 15936 - Instrumentation and Control Devices for HVAC.
      j. Section 15954 - Testing, Adjusting, and Balancing for HVAC.
      k. Section 16050 - Common Work Results for Electrical.
      l. Section 16060 - Grounding and Bonding.
      m. Section 16075 - Identification for Electrical Systems.
      n. Section 16123 - 600-Volt or Less Wires and Cables.
      o. Section 16130 - Conduits.
      p. Section 16134 - Boxes.
      q. Section 16140 - Wiring Devices.
      r. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      s. Section 16411 - Disconnect Switches.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9, Load Ratings and Fatigue Life for Ball Bearings.
   2. 11, Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc. (AMCA):
   1. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

2. 211, Certified Rating Program- Product Rating Manual for Fan Air Performance.
3. 300, Reverberant Room Method for Sound Testing of Fan.
4. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
1. 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
2. 68 - Laboratory Methods of Testing to Determine Sound Power in a Duct.

D. ASTM International (ASTM):
1. A 108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
2. D 4167 - Standard Specification for Fiber Reinforced Plastic Fans and Blowers.
3. E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

E. National Electrical Code (NEC).

F. National Electrical Manufacturers Association (NEMA):
1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

G. National Fire Protection Association (NFPA):
1. 90A - Standard for Installation of Air Conditioning and Ventilating Systems.
2. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

H. National Roofing Contractors Association (NRCA).

I. Occupational Safety and Health Administration (OSHA).

J. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As used in this Section and on the drawings, abbreviations and Fan Schedule headings have the following meaning:
1. SF or SPF: Supply Fan.
2. EF or EXF: Exhaust Fan.
3. Type: Fan type as specified in this Section.
4. SP or ESP: Fan External Static Pressure in inches water column.
5. Size: Nominal fan blade or wheel diameter in inches.
6. Hp: Fan motor horsepower.
7. V/Ph: Fan motor voltage and power phases.

B. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
2. Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:

1. Provide fans that have sharply rising pressure characteristics which extend throughout the operating range and continue to rise beyond the efficiency peak.
2. Provide fans that peak as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
3. When scheduled, provide guided vibration isolator for fans, so that not more than 10 percent of the vibration amplitude of the fan and motor is transmitted to the supporting structure.
4. Design fan inner scroll and air stream surfaces to maintain smoothness for entire fan service life.
5. Seismic supports: Seismic design criteria as specified in Section 01612.
6. Wind supports for exterior units: Wind design criteria as specified in Section 01614.
7. Electrical components: UL listed and meeting the design and installation requirements of the NEC.
8. Applicable portions as specified in Section 15050.
9. Motors supplied with fans: Manufacturer's standard when type not scheduled; provide motor voltage phases and speed as scheduled; motor not to be overloaded at any point on the fan curve including belt losses.
10. Roof curbs: Designed in accordance with NRCA standards.
11. Insulation and adhesives: Meet NFPA 90A requirements for flame spread and smoke generation.
12. Belt drive systems: Adjustable for minimum within 5 percent speed change, rated for 1.5 times maximum horsepower motor available for the scheduled fan size or model.
13. Screens: Provide bird or insect screen as specified with the fan type or as listed on the Fan Schedule:
    a. Bird screen: Stainless steel; 0.5-inch mesh 18 gauge.
    b. Insect screen: Stainless steel mesh and frame.
14. Finishes: When not specified with fan type, coat ferrous metals as specified in Section 09960.
15. Accessories: Provide accessories specified and those scheduled.
16. Provide fans with fire/smoke control system as specified under paragraph Fire/Smoke Control System Design Requirements.

B. Performance requirements:
1. Performance requirements are included in the Fan Schedule located at the end of this Section.
2. Fan performance: Rated and licensed to bear the AMCA label in accordance with AMCA 210 and AMCA 211.
3. Total sound power levels in the 8 octave band range as measured in accordance with ASHRAE 68, AMCA 301, or AMCA 300 as appropriate for each fan: Not to exceed the lesser of the following or the Sones levels on the Fan Schedule.

Sound Power Level, decibel levels referenced to 10-12 watts								
Frequency, Hz	63	125	250	500	1,000	2,000	4,000	8,000
General	100	98	94	88	84	84	78	75

4. Air filters supplied with fans: 25 to 30 percent dust spot efficiency when rated per ASHRAE Testing Standard 52.2.

5. Bearings: Rated per ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours; provide greater life when specified with each fan type.

C. Electrical and control system design:
   1. Design and supply necessary electrical power and control systems, components, and wiring to make a complete functioning system. Design to perform the system ventilating functions with the control systems as specified in Section 15936 or as indicated on the Drawings and as specified in the following Sections:
      a. Section 16050.
      b. Section 16060.
      c. Section 16075.
      d. Section 16123.
      e. Section 16130.
      f. Section 16134.
      g. Section 16140.
      h. Section 16222.
      i. Section 16411.

1.05 SUBMITTALS

A. Submit as specified in Section 01330.

B. Product data:
   1. Materials.
   2. Primary and ancillary equipment.
   3. Sound Power Level in each of 8 octave bands and overall Sones.
   4. Fan system layout, mechanical, electrical power, and control diagrams.
   5. Supports, vibration isolators, and seismic bracing calculations and details.
   6. Calculated fan vibration levels and field-testing method.
   7. Bearing life.
   8. Fan performance curves showing specified operating condition.

C. Provide vendor operation and maintenance manual as specified in Section 01782.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type fan.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756.

1.06 QUALITY ASSURANCE

A. Provide fans:
   1. Listed by UL.
   2. Rated in accordance with AMCA.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver units in 1 piece, factory assembled, internally wired, and lubricated.

B. Protect equipment from dust and atmospheric exposure as recommended by the unit manufacturer.
   1. As a minimum provide temporary closures for equipment openings designed for airflow.

1.08 EXTRA MATERIALS

A. Provide 2 extra sets (3 sets total) of filters per installed fan for fans specified with filters.

B. Provide 1 extra set of belts per installed fan for fans specified with belt drives.

PART 2 PRODUCTS

2.01 TYPE 14, CENTRIFUGAL SIDEWALL EXHAUST FANS

A. Manufacturers: One of the following or equal:
   1. Greenheck, Model CWB.
   2. Loren Cook, Model ACWB.
   3. Penn Ventilator.

B. Characteristics:
   1. Wall-mounted, upblast circular exhaust fan unit.
   2. Backward inclined centrifugal fan wheel with Venturi inlet; performance as scheduled.
   3. Materials: Aluminum fan, housing, and accessories.
   4. Fan bearings: Permanently lubricated ball bearing type.
   5. Adjustable belt drive rated for 150 percent of motor horsepower.
   6. Motor characteristics: As scheduled.
   7. Finishes: Provide Kynar paint coating over compatible primer on all steel surfaces.
   8. Provide duct adapter.
   9. Provide other accessories as scheduled.

C. Accessories:
   1. Mounting brackets: Necessary for installation.
   2. Bird screen: Provide bird screen if no screen is listed on the Fan Schedule.

2.02 Silicon controlled rectifier (SCR):

1. Manufacturers: One of the following or equal:
   a. GreenHeck, Model 10W.
   b. Penn Ventilator Lek-Trol Series.
2. Characteristics:
   a. Solid-state controller for use with 115 volt single phase shaded pole and open permanent split capacitor motors.
   b. Minimum 10 amp rating.
   c. Provide all necessary mounting boxes and hardware.
   d. Provide with manual speed adjustment knob and on/off control.

2.03 SOURCE QUALITY CONTROL

A. Factory test fans listed on the Fan Schedule for proper operation, performance, and electrical controls.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and verify that Work is in condition to receive installation specified in this Section.

B. Take measurements and verify dimensions to ascertain fit of installation.

C. Ascertain support and openings are correctly located.

3.02 PREPARATION

A. Before installation, remove dust and debris from equipment and ducts.

B. During installation and until equipment is operated, protect equipment and ducts from dust and debris by covering openings with tape or plastic.

3.03 INSTALLATION

A. Observe applicable installation requirements as specified in Section 15050.

B. Anchoring and support:
   1. Provide anchoring and support for fans and appurtenances.
   2. Provide anchoring to sustain seismic and wind forces as specified in Sections 01612 and 01614.

C. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

D. Install and wire unit fans and controls in accordance with manufacturer's recommendations.

E. Install flexible connections to fans.

F. Install roof curb and fan as recommended by fan manufacturer.

G. For fan housings with threaded water trap drain, provide drain piped from fan housing to the nearest drain channel, floor drain, or sump.

3.04 FIELD QUALITY CONTROL

A. Test equipment and installation to verify tightness, operation, and unit vibration is within manufacturer's submitted maximum.

B. Test equipment performance and balance equipment as specified in Section 15954.

3.05 COMMISSIONING AND PROCESS START-UP REQUIREMENTS

A. As specified in Section 01756 and this Section.

B. Manufacturer(each) services for each type of fan.
   1. Provide Manufacturer’s Certificate of Source Testing.

			Manufacturer Rep Onsite					
	Training Requirements		Installation Testing		Functional Testing		Process Operational Period	
Source Testing (Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)	Trips	Days (each trip)	Trips	Days (each trip)	Trips	Days (each trip)
Non-Witnessed	Not Required		Not Required		Not Required		Not Required	

3.06 SCHEDULES

A. Fan Schedule:

Equip. No.	Location	Fan							Motor			Additional Requirements (See listed Notes)
		Type	Drive	Min. CFM	Min. ESP"	Max. RPM	Fan Diam.	Noise Sones	Hp	V / Ph.	Max. RPM	
EF-1	NaOH room	14	Direct	250	0.2	1470	8	4.1	1/6	120/1	1725	11,
EF-2	NaOH room	14	Belt	2,750	0.25	1610	14.5	19.0	3/4	280/3	1725	

Notes:

1. Provide bird screen.
2. Provide insect screen.
3. Provide backdraft damper, counterbalanced for minimum pressure loss.
4. Provide exterior weather hood.
5. Provide adjustable belt sheaves.
6. Provide vibration isolators.
7. Provide manufacturer std. motor enclosure.
8. Provide TEFC motor enclosure and wiring suitable for Class I, Div. 2 locations.
9. Provide explosion proof motor and wiring suitable for Class I, Div. 1 locations.
10. Provide variable frequency drive speed controller as specified in this Section.
11. Provide SCR speed controller as specified in this Section.
12. Provide exterior disconnect switch at fan, NEMA Type 3R.
13. Provide NEMA Type 1 disconnect switch at fan inside housing.
14. Provide 120 volt, line voltage thermostat Type 2 as specified in Section 15936.
15. Provide 24 volt, low voltage thermostat type T-5 as specified in Section 15936.
16. Interlock fan with motorized louver dampers, other fans, or equipment as indicated on the Drawings.
17. Provide replaceable filters.
18. Provide motorized backdraft damper.
19. Provide exterior weather louver, Type L-1 as specified in Section 15852.
20. Provide fiberglass canopy hood, size as indicated on the Drawings.
21. Fan selection based on existing opening; field verify opening size and select maximum sized, slowest rpm fan to fit opening and meet performance conditions.
22. Provide fire/smoke control system for all fans greater than 2,000 cfm.

SECTION 15852

LOUVERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Stationary weather louvers.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 15954 - Testing, Adjusting, and Balancing for HVAC.

1.02 REFERENCES

A. Air Movement and Control Association International, Inc. (AMCA):
   1. 500-L - Laboratory Methods of Testing Louvers for Rating.
   2. 500-D - Laboratory Methods of Testing Dampers for Rating.
   3. 511 - Certified Ratings Program - Product Rating Manual for Air Control Devices.

B. ASTM International (ASTM):
   1. D 2584 - Standard Test Method for Ignition Loss of Cured Reinforced Resins.

C. Underwriters Laboratories, Inc. (UL).

1.03 PERFORMANCE REQUIREMENTS

A. Performance: In accordance with AMCA 511 when tested in accordance with AMCA 500.

B. Designed for 20 pounds per square foot wind load.

1.04 SUBMITTALS

A. Shop drawings: Include dimensions, anchorage details, and relationships to adjacent materials.

B. Product data.

1.05 QUALITY ASSURANCE

A. Provide louvers with the following, unless otherwise specified:
   1. AMCA certification and rating in accordance with AMCA 511 for air performance and water penetration.

PART 2 PRODUCTS

2.01 GENERAL

A. Louver types: Louvers are marked on the drawings with a letter L followed by a number referring to a louver type in this Section. Individual louver size and airflow rates are as indicated on the Drawings.

B. Accessories:
   1. Provide installation clips and flanged or jamb-mounting styles suitable for the mounting locations as indicated on the Drawings.
   2. Provide extended sills for louvers indicated as installed recessed from the exterior wall surface.
   3. Provide stainless steel fasteners unless noted otherwise.
   4. Corrosion protection.
   5. Provide gravity damper for all outside air intake and exhaust louvers unless noted otherwise.

C. Protective coatings for aluminum in contact with concrete or masonry:
   1. Manufacturers: One of the following or equal:
   2. Koppers Company, Inc.
   3. Tarmastic 100.
   4. Porter Coatings.

2.02 STATIONARY WEATHER LOUVERS, TYPE L-1

A. Manufacturers: One of the following or equal:
   1. Ruskin, Model ELF 6375DXH.
   2. Airolite Company, equivalent product.
   3. American Warming and Ventilating, Inc., equivalent product.

B. Requirements:
   1. Type: Stationary louver with drainable blades.
   2. Frame: 6 inches deep, minimum 0.125-inch thick, Type 6063-T5 aluminum with downspouts and caulking channel provided.
   3. Blades: Minimum 0.125-inch thick, Type 6063-T5 aluminum drainable blades, stationary mounted at 37.5 degrees.
   4. Screens: Removable aluminum frame with aluminum wire; insect screens on intakes and bird screens on exhausts.
   5. Pressure drop (without screen): Maximum 0.12-inch water column for exhaust service and 0.15-inch water column for intake service at 1,000 feet per minute free area velocity.
   6. Water penetration: Maximum 0.01-ounce water per square foot at 1,014 feet per minute free area velocity.
   7. Mullions: Hidden.
   8. Finish: Kynar finish**;** color as selected.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install louvers in accordance with manufacturer's instructions; caulk all frames to make weathertight.

B. Install louvers for machinery, engines, and similar equipment to allow easy louver removal for machinery or engine removal through the louver opening space without louver projections on floors or walls.

C. Anchor louvers to concrete or masonry with concrete anchors through jambs.

D. Corrosion protection:
   1. Aluminum in contact with concrete or masonry: Apply 2 coats bitumastic black solution.
   2. Aluminum in contact with dissimilar metal, except stainless steel: Isolate from dissimilar metal with neoprene gaskets, sleeves, or washers. Utilize stainless steel fasteners.
   3. Field-testing: As specified in Section 15954.

END OF SECTION

SECTION 15954

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Heating, ventilation, and air conditioning systems testing, adjusting, and balancing.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01756 - Commissioning and Process Start-Up.

1.02 REFERENCES

A. Associated Air Balance Council (AABC):
   1. National Standards for Field Measurements and Instrumentation, Total System Balance, Air Distribution-Hydronic Systems.

B. National Environmental Balancing Bureau (NEBB):
   1. Procedural Standards for Testing, Adjusting, and Balancing Environmental Systems.

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. Heating, Ventilating, and Air Conditioning Systems - Testing, Adjusting, and Balancing.

D. Testing, Adjusting, and Balancing Bureau (TABB):
   1. International Standards for Environmental Systems Balance.

1.03 TESTING, ADJUSTING, AND BALANCING WORK REQUIREMENTS

A. Procure the services of an independent air balance and testing agency belonging to and in good standing with the AABC, NEBB, or the TABB to perform air and hydronic balancing, testing, and adjustment of building and process air conditioning, heating, and ventilating air systems.

B. The Work includes: Balancing new air and hydronic systems installed as part of this contract and existing air and hydronic systems affected by the installation of new equipment.

C. Perform testing of heating, ventilating, and air conditioning equipment, balancing of distribution systems, and adjusting of air terminal units and ductwork accessories to ensure compliance with Specifications and Drawings. Perform tests for following:
   1. Air conditioning units.
   2. Heat pump units.
   3. Central station air handlers.
   4. Evaporative coolers.
   5. Heating units.
   6. Fans.
   7. Odor scrubber fans.
   8. Condensers.
   9. Air terminal units.
   10. Ductwork accessories.
   11. Ducting.
   12. HVAC controls.
   13. Other specified HVAC equipment.

D. Test hydronic systems, and adjust and record liquid flow at each piece of equipment to ensure compliance with Specifications and the Drawings. Perform test for following:
   1. Circulating pumps.
   2. Circuit setting valves.
   3. 3-way mixing valves.
   4. Hot water coils.
   5. Chilled water coils.
   6. Other specified hydronic system components.

E. Test each mode of operation of thermostats, electronic controllers, and pneumatic, electric or electronic heating, ventilating, and air conditioning instruments to ensure operation as specified.

F. Test and adjust room distribution patterns at air outlets.

G. Provide instruments required for testing, adjusting, and balancing operations; retain possession of instruments; remove instruments from site at completion of services.

H. Make instruments available to the Engineer to facilitate spot checks during testing.

I. Provide test holes for pressure and pitot flow measurements; provide plugs for all test holes after testing.

1.04 QUALITY ASSURANCE

A. Test, balance, and adjust environmental systems in accordance with either:
   1. AABC: National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronics System.
   2. NEBB: Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
   3. TABB: International Standards for Environmental Systems Balance.

B. Perform services under direction of AABC, NEBB, or TABB certified supervisor.

C. Calibrate and maintain instruments in accordance with requirements of standards. Make calibration histories of instruments available for examination.

D. Make measurements in accordance with accuracy requirements of standards.

E. Testing, adjusting, and balancing performance requirements:
   1. Comply with procedural standards of certifying association.
   2. Execute each step of prescribed testing, balancing, and adjusting procedures without omission.
   3. Accurately record required data.
   4. Make measurements in accordance with recognized procedures and practices of certifying association.
   5. Measure air volume discharged at each outlet and adjust air outlets to design air volumes within 5 percent over.

1.05 SUBMITTALS

A. Resumes of proposed supervisor and personnel showing training and qualifications.

B. Interim reports: At least 30 days prior to starting field work, submit the following:
   1. Set of report forms filled out as to design flow values and installed equipment pressure drops, and required cubic feet per minute for air terminals.
   2. Develop heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.
   3. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
      a. Manufacturer and model number.
      b. Description and use when needed to further identify instrument.
      c. Size or capacity range.
      d. Latest calibration date.

C. Final report: At least 15 days prior to Contractor's request for final inspection, submit 3 copies of final reports, on applicable reporting forms. Include:
   1. Identify instruments which were used and last date of calibration of each.
   2. Procedures followed to perform testing, adjusting, and balancing.
   3. Identification and succinct description of systems included in report.
   4. Initial balance test results made with all dampers and air control devices in full open positions.
   5. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
   6. Description of final location and opening positions of dampers, registers, louvers, and valves.
   7. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
   8. Testing, adjusting, and balancing report forms.
   9. Final field results established for system balancing including airflow, fan speeds, and fan static pressures at the fan inlet and outlet.
   10. Appendices.
   11. Include appendices for:
      a. Raw field data taken during testing.

b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
c. Initial air balance results with dampers and registers in full open position; include airflow at all inlets and outlet, initial fan speed and fan suction and discharge pressures.

D. Proposed schedule for testing and balancing.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756.

1.06 SITE CONDITIONS

A. Prior to start of testing, adjusting, and balancing, verify that:
1. Systems installation is complete and in full operation.
2. Outside conditions are within reasonable range relative to design conditions.
3. Lighting fixtures are energized.
4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
5. Requirements for preparation for testing and balancing have been met for elements of each system which require testing.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Perform Functional Tests as specified in Section 01756.

B. Testing, adjusting, and balancing acceptance criteria: Consider testing, adjusting, and balancing procedures successful and complete when heating, ventilating, and air conditioning systems and components are functioning properly and system air and water flows are within specified tolerances of design flows.

3.02 TESTING, ADJUSTING, AND BALANCING

A. Test, adjust, and balance separate complete heating, ventilating, and air conditioning systems.

B. Include in testing, adjusting, and balancing related existing heating, ventilating, and air conditioning components.

C. Perform testing, adjusting, and balancing cycles until airflows meet acceptance criteria.
1. Ascertain airflow balance between overall requirements and flow in individual supply and exhaust grilles.

D. Initial testing, adjusting, and balancing: Perform first test on each system with dampers, grilles, orifices, and other variable airflow devices in their full open position; measure and report initial airflows, fan speed, and fan static pressures at fan inlet and outlet.
   1. Adjust total system flow downward or upward by adjusting fan speed until 1 inlet or outlet is at indicated flow and all other flows exceed indicated flows.
   2. Adjust fan speed by changing fan drives or sheaves as necessary.

E. Subsequent testing, adjusting, and balancing: Perform adjustments in subsequent testing, adjusting, and balancing by adjusting dampers, louvers, or size of orifices or plates.
   1. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
   2. Adjust fan speeds and motor drives within drive limitations, for required air volume.
   3. Measure cubic feet per minute and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.
   4. Measure and record static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
   5. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
   6. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
   7. Permanently mark final balance positions of balancing dampers.

F. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.

G. Accurately record the required data on AABC, NEBB, or TABB test and balance report forms.

H. Measure amperage draw of fan and pump motors for final balance.

I. Following completion of balancing procedures for air systems, test, adjust, and balance hydronic systems.
   1. Measure flow and adjust circuit setter valves so pumps deliver at least 100 percent of the design water flow.
   2. Measure and adjust water flow at coils for design conditions, within 5 percent. Check conditions at cooling and heating coils for required performance at design conditions.
   3. Lock balance valves in the adjusted position and permanently mark the design set point.
      a. Record valve settings in the design report.

J. Test primary source equipment in accordance with AABC, NEBB, or TABB procedures.
   1. Primary source equipment includes items listed in this Section not previously tested as part of this testing, adjusting, and balancing work.
   2. Complete appropriate AABC, NEBB, or TABB equipment test forms for each piece of equipment.

3. Calculate cooling and heating capacities to show conformance with specified capacities.
4. Adjust equipment as needed to deliver specified cooling and heating loads.
5. Record final equipment performing characteristics and adjustment settings in the final design report.

END OF SECTION

SECTION 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01410 - Regulatory Requirements.
      c. Section 01500 - Temporary Facilities and Controls.
      d. Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052; are specified in the specifications covering the various types of piping; and are specified in this Section.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01410, and UL requirements.
   4. Test natural gas or digester gas piping:

a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410, or the National Fuel Gas Code, whichever is more stringent.
b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.

5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
   a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water may be disposed of by discharging into the treatment process at a convenient location at the headworks or upstream of the primary clarifiers. Discharging test water downstream of the primary clarifiers is prohibited.

1.04 SUBMITTALS

A. Submit as specified in Section 01330.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 15052:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASE B31.8, or the pipe manufacturer's stated maximum working pressure.

3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
4. Perform initial check of joints and fittings for leakage.
5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure reached.
6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) For polyvinyl chloride (PVC) gravity sewer pipe: 25 gallons per day per inch diameter per mile of piping under test:
            a) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
               (1) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
                  (a) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
               (2) For vitrified claypiping: 500 gallons per day per inch of diameter per mile of piping under test.
               (3) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
   1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
   2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
   3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
   4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
   5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
   6. When test results indicate failure of selected sections, limit tests to piping:
      a. Between valves.
      b. Between a valve and the end of the piping.
      c. Less than 500 feet long.
   7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
   1. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
   3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
      a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
   2. Pressure test piping after completion of visible leaks test.
   3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
      b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
      c. When leakage is allowed, calculate the allowable leakage by the following formula:

         $L = S \times D \times P^{1/2} \times 133{,}200^{-1}$

         wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 15052.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
   1. Subject piping under test to the specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
      b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:
   1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low head pressure piping.
      b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
   2. Joint testing may be performed with water or air.
   3. Joint test piping after completion of backfill and compaction to the top of the trench.
   4. Joint testing with water:
      a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
      b. Maintain test pressure for 1 minute.
      c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
      d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
      e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
   5. Joint testing with air:
      a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
      b. Maintain test pressure for 2 minutes.
      c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01756 - Commissioning and Process Start-Up.
      b. Section 02318 - Trenching.
      c. Section 15956 - Piping Systems Testing.
      d. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

C. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. Schedule of source (factory) tests, Owner training, installation testing, functional testing, clean water facility testing, closeout documentation, process start-up and process operational period as specified in this Section and in Section 01756 and equipment sections.

B. Test instrumentation calibration data.

C. Commissioning and Process Start-up Plan: As specified in Section 01756.

D. Test plan as specified in Section 01756 and equipment sections.

E. Test reports as specified in this Section and in Section 01756 and equipment sections.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning and process start-up of equipment as specified in:
   1. This Section.
   2. Section 01756.
   3. Equipment sections.
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Comply with latest version of applicable standards.

C. Test and prepare piping as specified in Sections 02318 and 15956.

D. Operation of related existing equipment: Owner will operate related existing equipment or facilities necessary to accomplish the testing. Schedule and coordinate testing as required by Section 01756.

E. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

F. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

G. Report features:
   1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
   2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
   3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
   4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.

5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

H. Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing.
   1. With Owner's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.

I. Prepare and submit test reports as specified.

J. Testing levels
   1. Level 1 Tests:
      a. Level 1 General Equipment Performance Test:
         1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
      b. Level 1 Pump Performance Test:
         1) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
         2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 or the applicable equipment section. Use actual driver for field tests.
         3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
      c. Level 1 Vibration Test:
         1) Test requirement:
            a) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
            b) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
         2) Equipment operating condition: Test at specified maximum speed.
      d. Level 1 Noise Test:
         1) Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.
   2. Level 2 Tests:
      a. Level 2 General Performance Test:

1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
2) Operate at rated design load conditions.
3) Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Level 2 Pump Performance Test:
1) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.
3) Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

c. Level 2 Vibration Test:
1) Test requirement:
a) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
b) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
2) Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
3) Natural frequency test of field installed equipment:
a) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears and supports.
b) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
c) Perform with equipment and attached piping full of intended service or process fluid.

d. Level 2 Noise Test:
1) Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

3. Level 3 Tests:
    a. Level 3 General Equipment Performance Tests:
        1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
        2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
        3) Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration or temperatures are observed.
        4) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
        5) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
    b. Level 3 Pump Performance Test:
        1) Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
        2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.
        3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
        4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
    c. Level 3 Vibration Test:
        1) Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
        2) Perform High Frequency Enveloping Analysis for gears and bearings.
            a) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
            b) Report results in units of acceleration versus frequency in cycles per minute.
        3) Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).

4) Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.

d. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.

4. Level 4 Tests:
   a. Level 4 General Equipment Performance Test:
      1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
      2) Operate at rated design load conditions for1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
      3) Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration or temperatures are observed.
      4) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
      5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
   b. Level 4 Pump Performance Test:
      1) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
      2) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration and noise data at each test condition.
      3) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
      4) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
      5) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
         a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.

b) Perform efficiency testing with test fluids at maximum rated speed.
c) Perform priming time testing with test fluids at maximum rated speed.

c. Level 4 Vibration Test: Same as Level 3 vibration test.
d. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

K. Variable speed equipment tests:
1. Establish performance over the entire speed range and at the average operating condition.
2. Establish performance curves for the following speeds:
a. The speed corresponding to the rated maximum capacity.
b. The speed corresponding to the minimum capacity.
c. The speed corresponding to the average operating conditions.

L. Pump tests, all levels of testing:
1. Test in accordance with the following:
a. Applicable HI Standards.
b. This Section.
c. Equipment sections.
2. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
a. From 0 to plus 5 percent of head at the specified flows.
b. From 0 to plus 5 percent of flow at the rated design point head.
c. No negative tolerance for the efficiency at the specified flows.
d. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

M. Drivers tests:
1. Test motors as specified in Section 16222.
2. Test other drivers as specified in the equipment section.

N. Noise requirements and control:
1. Perform noise tests in conjunction with vibration test analysis.
2. Make measurements in relation to reference pressure of 0.0002 microbar.
3. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
4. Set sound level meter to slow response.
5. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

O. Pressure testing:
1. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

P. Inspection and balancing:
1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

2. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
3. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

Q. Critical speed of rotating equipment:
1. Satisfy the following:
   a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
   b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
   c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

R. Vibration tests:
1. Definitions:
   a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
   b. Peak-to-peak displacement: The root mean squared average of the peak-to-peak displacement multiplied by the square root of 2.
   c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
   d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
   e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
      1) Manufacturers: One of the following or equal:
         a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
         b) CSI, "PeakVue."
   f. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
   g. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
   h. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
   i. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.
2. Vibration instrumentation requirements:
   a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12 bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles

per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.

1) Manufacturers: One of the following or equal:
    a) Entek-IRD, Division of Rockwell Automation, Enpac 1200 with applicable data analysis software or Entek Model 838 analyzer.
    b) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
    c) Pruftechnik, VIBXPERT II.

b. Analyzer settings:
    1) Units: English, inches/second, mils, and gravitational forces.
    2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
    3) Sample averages: 4 minimum
    4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
    5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
    6) Fast fourier transform windowing: Hanning Window.
    7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.

c. Accelerometers:
    1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
        a) Manufacturers: One of the following or equal:
            (1) Wilcoxon Research, Model 797L.
            (2) PCB, Model 393C.
    2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
        a) Manufacturers: One of the following or equal:
            (1) Wilcoxon Research, Model 793.
            (2) Entek-IRD Model 943.

3. Accelerometer mounting:
    a. Use magnetic mounting or stud mounting.
    b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
    c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
4. Vibration acceptance criteria:

a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions & Application Data	**Overall Peak-to-Peak Displacement**	
	Field, mils	**Factory, mils**
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	**Horsepower**	**Field Test**	**Factory Test**
		Overall RMS	**Overall RMS**
Horizontal Solids Handling Centrifugal Pumps	Below 33 HP	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	Between 33 and 100 HP	0.28	0.31
	100 HP and above	0.31	0.34
Vertical Solids Handling Centrifugal Pumps	Below 33 HP	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps	Between 33 and 100 HP	0.32	0.35
	100 HP and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps	Below 268 HP	0.15	0.19
HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	268 HP and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 HP	0.13	
Gear Reducers, Radial	268 HP and above	0.17	

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:

1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.

2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.

3) For motors, the following shall be cause for rejection:

a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.

b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.

c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.

d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.

4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:

a. Provide equipment drawing with location and orientation of measurement points indicated.

b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.

c. When Vibration Spectra Data required:

1) Plot peak vibration velocity versus frequency in cycles per minute.
2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
4) Plot motor spectra on a log amplitude scale versus frequency.

d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.02 PLANNING PHASE

A. Submit test plans as specified in Section 01756 and this Section.
1. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on Owner's existing equipment and other information relevant to the test.
2. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.

3.03 COMMISSIONING PHASE

A. Source testing
1. Witnessing not required unless specified otherwise in equipment section.
2. Witnessed tests: Schedule test date and notify Engineer at least 30 days prior to start of test.
3. Test equipment as specified in Section 01756 and equipment sections.
4. Test fluids as specified in Section 01756.
5. Submit reports as specified in Section 01756

B. Installation testing:
1. Test equipment as specified in Section 01756 and equipment sections.

C. Functional testing:
1. Witnessing required as specified in Section 01756.
2. Schedule test date and notify Engineer at least 7 days prior to start of test.
3. Test equipment as specified in equipment sections. Test fluids as specified in Section 01756.
4. Submit reports as specified in Section 01756.

D. Clean Water Facility Testing
1. Test equipment as specified in Section 01756 and equipment sections.

E. Closeout documentation
1. Provide closeout documentation as specified in Section 01756 and equipment sections.

3.04 PROCESS START-UP PHASE

A. Process start-up:
   1. Process start-up equipment as specified in Section 01756 and equipment sections.

B. Process Operational Period:
   1. Operate equipment as specified in Section 01756 and equipment sections.
   2. Test fluids as specified in Section 01756.

END OF SECTION

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Electrical Work.
   2. General requirements for electrical submittals.

B. Pre-Bid Site Visit and pre-bid conference:
   1. The electrical subcontractor is required to visit the site prior to the bid**,** and attend a pre-bid conference and examine the premises completely before bidding. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations

C. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Document 00700 - General Conditions.
      b. Section 01140 - Work Restrictions.
      c. Section 01292 - Schedule of Values.
      d. Section 01312 - Project Meetings.
      e. Section 01324A - Progress Schedules and Reports.
      f. Section 01324B - Progress Schedules and Reports.
      g. Section 01324C - Progress Schedules and Reports.
      h. Section 01329 - Safety Plan.
      i. Section 01330 - Submittal Procedures.
      j. Section 01410 - Regulatory Requirements.
      k. Section 01450 - Quality Control.
      l. Section 01610 - Project Design Criteria.
      m. Section 01612 - Seismic Design Criteria.
      n. Section 01614 - Wind Design Criteria.
      o. Section 01738 - Selective Site Demolition.
      p. Section 01770 - Closeout Procedures.
      q. Section 01782 - Operation and Maintenance Data
      r. Section 16075 - Electrical Identification.
      s. Section 16130 - Conduits.
      t. Section 16210 - Utility Coordination.
      u. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      v. Section 16305 - Electrical System Studies.
      w. Section 16422 – Motor Starters

x. Section 16950 - Field Electrical Acceptance Tests.

D. Interfaces to equipment, instruments, and other components:
   1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer's wiring requirements.
   3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.

E. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
   3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

F. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.

2. Specifications:
    a. The General and Supplementary Conditions of the Contract Documents govern the Work.
    b. These requirements are in addition to all General Requirements.
3. Contract Drawings:
    a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
    b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
        1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
        2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
    c. Installation details:
        1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
    d. Schematic diagrams:
        1) All controls are shown de-energized.
        2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
        3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
        4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
        5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

G. Alternates/Alternatives:
    1. Coordinate with Document 00700 for substitute item provisions.

H. Changes and change orders:
    1. As specified in Document 00700.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410.
   2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
   3. The standards listed are hereby incorporated into this Section.
      a. American National Standards Institute (ANSI).
      b. American Society of Civil Engineers (ASCE):
         1) Minimum Design Loads for Buildings and Other Structures.
      c. ASTM International (ASTM).
      d. Illuminating Engineering Society (IES). Institute of Electrical and Electronics Engineers (IEEE).
      e. Insulated Cable Engineers Association (ICEA).
      f. International Code Council (ICC).
         1) International Code Council Evaluation Service (ICC-ES).
            a) AC 156 – Acceptance Criterai for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
      g. International Society of Automation (ISA).
      h. National Electrical Manufacturers Association (NEMA):
         1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
      i. National Fire Protection Association (NFPA):
         1) 70 - National Electric Code (NEC).
      j. National Institute of Standards and Technology (NIST).
      k. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:
   1. As specified in Document 00700.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
   1. IEEE.
   2. NETA.
   3. IES.
   4. ISA.
   5. NEC.
   6. NEMA.
   7. NFPA.
   8. NIST.

B. Specific definitions:
   1. FAT: Factory acceptance test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
   4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   5. PCIS: Process control and instrumentation system.

6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
      a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
   2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
   3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work, including heating, ventilating, and air conditioning.
   4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.
   5. Demolition:
      a. Where demolition is specified or indicated on the Drawings, disconnect all associated electrical equipment and render the equipment safe.
      b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
      c. Salvage electrical equipment as specified in [Section 01738.
      d. For each piece of equipment to be removed, remove all ancillary components (e.g. instruments, solenoid valves, disconnect switches, etc.).
      e. Conduit:

1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
    a) Remove exposed conduit to the point of encasement or burial.
    b) Cut conduit flush and plug or cap encased or buried conduit.
2) Where conduits are to remain in place and removal is not indicated on the Drawings:
    a) Cap conduit open ends.
    b) Re-label empty conduits as spare.

f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
h. Provide new typewritten schedules for all modified panelboards.

6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
    b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
7. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
    a. As specified in the Contract Documents.
8. Defective work:
    a. As specified in Document 00700.
9. Utility coordination: Coordinate with the electric and telephone utilities as required by Section 16210.

B. Existing system: (NOT USED)

C. New system: (NOT USED)

D. Operating facility: (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 and this Section.

B. General:
1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
2. Furnish the submittals required by each section in the Electrical Specifications.
3. Adhere to the wiring numbering scheme specified in Section 16075 throughout the Project:
    a. Uniquely number each wire.
    b. Wire numbers must appear on all Equipment Drawings.

4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Seismic requirements:
   1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01614.
   2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
      a. Statement of seismic qualification, and special seismic certification:
         1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410, including the requirements of ASCE 7, Chapter 13.
         2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with Ip = 1.5." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
      b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
      c. Anchoring design calculations and details:
         1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612.
   3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
      a. Temporary or moveable equipment.
      b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
      c. Distribution equipment anchored to the structure and having a total unit weight of 5 pounds per linear foot, or less.

D. Submittal organization:
   1. First page:
      a. Specification section reference.
      b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
      c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
      d. Place for Contractor's review stamp and comments.
   2. Next pages:
      a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.

b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
    1) In the order that the comments or questions were presented throughout the submittal.
    2) Referenced by index section and page number on which the comment appeared.
    3) Acceptable responses to Engineer's comments are either:
        a) Engineer's comment or change is accepted and appropriate changes are made.
        b) Explain why comment is not accepted or requested change is not made.
        c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
    4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
    5) No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:
    a. Actual submittal data:
        1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal requirements:
1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
    a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submit copies of shop drawings, and product data:
    a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
    a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:

a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
c. Acceptance of any exception is at the sole discretion of the Engineer.
    1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

7. Specific submittal requirements:
    a. Shop drawings:
        1) Required for materials and equipment listed in this and other sections.
        2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
        3) Shop drawings requirements:
            a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
            b) Locations of conduit entrances and access plates.
            c) Component layout and identification.
            d) Schematic and wiring diagrams with wire numbers and terminal identification.
            e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
            f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
            g) Weight.
            h) Finish.
            i) Nameplates:
                (1) As specified in Section 16075.
            j) Temperature limitations, as applicable.
    b. Product data:
        1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
        2) Include:
            a) Catalog cuts.
            b) Bulletins.
            c) Brochures.
            d) Quality photocopies of applicable pages from these documents.
            e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
            f) Identify model number and options for the actual equipment being furnished.
            g) Neatly cross out options that do not apply or equipment not intended to be supplied.
    c. Detailed sequence of operation for all equipment or systems.
    d. Completed Motor Data Sheet, as specified in Section 16222, for every motor furnished:

1) Submit one copy of the Motor Data Sheet to the Engineer for review as part of the associated equipment submittal.

F. Operation and maintenance manuals:
   1. As specified in Section 01782.
   2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before energization start-up and/or commissioning.
   3. Additional operation and maintenance manual requirements:
      a. Completely index manuals with a tab for each section:
         1) Each section containing applicable data for each piece of equipment, system, or topic covered.
         2) Assemble manuals using the approved shop drawings, and include, the following types of data:
            a) Complete set of 11-inch by 17-inch drawings of equipment.
            b) Complete set of 11-inch by 17-inch drawings of the control system.
            c) Complete set of control schematics.
            d) Complete parts list for all equipment being provided.
            e) Catalog data for all products or equipment furnished.

G. Material and equipment schedules:
   1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
      a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

H. Schedule of values:
   1. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

I. Roof penetrations:
   1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

J. Record Documents:
   1. Furnish as specified in Section 01770.
   2. Provide Record Documents of all Electrical Drawings.
   3. Record Drawing requirements:
      a. Update Record Drawings weekly.
      b. Record Drawings must be fully updated as a condition of the monthly progress payments.
      c. Submit Record Drawings upon completion of the Work for final review.
      d. Clearly and neatly show all changes including the following:

1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.

4. Shop drawings:
   a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
      1) Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch using Bond paper.
      2) Provide electronic copies of these documents on CD-ROM disks in AutoCad Version 2000 by Autodesk. Size all drawings to be readable and legible on 11-inch by 17-inch media.
   b. Furnish written information prepared specifically for this Project using .pdf and printed on 8.5-inch by 11-inch plain bond paper:
      1) Provide electronic copies of these documents on CD-ROM disks.
5. Review and corrections:
   a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   b. Promptly correct and re-submit record documents returned for correction.

K. Test reports:
   1. As specified in Section 01330**.**
   2. Include the following:
      a. A description of the test.
      b. List of equipment used.
      c. Name of the person conducting the test.
      d. Date and time the test was conducted.
      e. All raw data collected.
      f. Calculated results.
      g. Each report signed by the person responsible for the test.
   3. Additional requirements for acceptance test reports are specified in Section 16950.

L. Calculations:
   1. Where required by specific Electrical Specifications:
      a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

M. Factory acceptance test:
   1. As specified in Section 01330**.**
   2. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

B. System supplier responsibilities:
   1. Requirements as specified in the Instrumentation and Control Specifications.
   2. System supplier:
      a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and Instrumentation and Control Specifications,

and shown on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.

3. Contractual relationship:
   a. Form a contractual relationship between the electrical subcontractor and the ICSC.
   b. Requirements for the first tier subcontractor:
      1) Contract directly with the Contractor.
      2) Be either the electrical subcontractor or the ICSC.
   c. Requirements for the second tier subcontractor:
      1) A division of the first tier subcontractor, or
      2) A joint venture with the first tier subcontractor, or
      3) A subcontractor to the first tier subcontractor.
   d. The system supplier manages, directs, and supervises all of the Work of its second tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system, including, but not limited to, all Electrical, Instrumentation, and Process Contract Drawings, Electrical Specifications, and Instrumentation and Control Specifications:
      1) Provide any additional conduit, wire, etc.
      2) Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.
      3) Ensure compatibility between the PCIS system and the electrical system being installed.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Shipping precautions:
   1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
   2. Place dehumidifiers, when required, inside the polyethylene coverings.
   3. Skid-mount the equipment for final transport.
   4. Provide lifting rings for moving without removing protective covering.
   5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

B. Delivery and inspection:
   1. Deliver products in undamaged condition, in manufacturer’s original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

C. Special instructions:
   1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:

1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
2. Ambient Temperature (outdoors):
    a. The ambient temperature for this project is 30 to 120 degrees Fahrenheit.
3. Seismic load resistance:
    a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612.
4. Wind load resistance:
    a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01614.
5. Altitude, temperature and humidity:
    a. As specified in Section 01610.
    b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
    c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
        1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
6. Site security:
    a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329.
7. Outdoor installations:
    a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
    b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
        1) Provide all wiring necessary to power these devices.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
3. NEMA Type 4X: Made from corrosion resistant materials (fiberglass reinforced plastic, 316 stainless steel or equal) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

5. NEMA Type 6: Rated for submergence.
6. NEMA Type 6P: Rated for prolonged submergence.

C. Plant area Electrical Work requirements:
1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Injection Well Supply Pump Station	NEMA 4X Stainless Steel	PCS	X, W	316 Stainless Steel
Sodium Hypochlorite Generation Facility	NEMA 4X Fiberglass	PCS	X	Fiberglass
Electrical Buildings	NEMA 12	GRC	C	Galvanized Steel
Outdoor Areas at WWRP	NEMA 4X Stainless Steel	PCS	X, W	316 Stainless Steel
Well Sites	NEMA 4	GRC	W	Galvanized Steel

2. Modify exposed conduit runs as specified in Section 16130.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
1. As specified in Section 01312.
2. Testing requirements are specified in Section 16950 and other sections.
3. General scheduling requirements are specified in Sections 01324A,01324B, and 01324C.
4. Work restrictions and other scheduling requirements are specified in Section 01140.

B. Pre-submittal conference:
1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend, including but not limited to:

a. Vendor control panels.
b. Chemical feed systems.
c. Variable frequency drives.
d. Lighting.

C. Factory acceptance testing:
1. Where factory acceptance testing is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
a. Indicate the desired dates for inspection and testing.
b. Schedule the FAT after approval of the FAT procedures submittal:
1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in Document 00700:
1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in Document 00700.

C. Stainless steel:
   1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.
   3. Provide finished material free of any burrs or sharp edges.
   4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
   5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
   6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

B. Arrange with all manufacturers of the electrical equipment, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
   1. Testing includes the cabinets, special control systems, power equipment, and other pertinent systems and devices.

C. Factory testing is specified in the individual sections of the Electrical Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. The electrical subcontractor is required to visit the site prior to the bid**, and** attend a pre-bid conference and examine the premises completely before bidding. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

C. Provide a complete electrical system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, PCIS, and HVAC system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. Cutting and patching:
   1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
      a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
         1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
            b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
      b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
   2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all

conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
   a. 3M CP 25WB+ Caulk.
   b. 3M Fire Barrier Putty.
3. Seal around conduit penetrations of below grade walls with a waterproof, non-shrink, non-metallic grout, unless otherwise indicated on the typical installation details:
   a. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
   1. Install all conduits and equipment in accordance with working space requirements as outlined in the NEC.
      a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
   2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
      a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
   3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
   4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

E. Earthwork and concrete:
   1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
      a. Requirements as specified in the Contract Documents.

F. Roof penetrations:
   1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.

G. Terminations:
   1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

H. Miscellaneous installation requirements:
   1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 00700.
   2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
   3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
   4. Circuits of different service voltage:
      a. Voltage and service levels:
         1) Low voltage: 120 V to 480 V.

2) Instrumentation: Less than 50 VDC.

b. Install different service voltage circuits in separate raceways, junction boxes, manholes, hand holes, and pullboxes.

c. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.

I. Labeling:

1. Provide all nameplates and labels as specified in Sections 16075 and Section 16305.

J. Equipment tie-downs:

1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Inspection:

1. Allow for inspection of electrical system installation as specified in Section 01450.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
   a. Inspect equipment and materials for physical damage.
   b. Inspect installation for compliance with the Drawings and Specifications.
   c. Inspect installation for obstructions and adequate clearances around equipment.
   d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
   e. Inspect equipment nameplate data to verify compliance with design requirements.
   f. Inspect raceway installation for quality workmanship and adequate support.
   g. Inspect cable terminations.
   h. Schedule structural engineer to inspect all mounting of electrical devices and all penetration and connections to structures.
4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950.

B. Field testing:

1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the acceptance tests as specified in Section 16950.
3. Record results of the required tests along with the date of test:
   a. Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:
   1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
      a. Neatly coil and label spare wiring lengths.
      b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 01770**.**

B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
   1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean and re-lamp all new and existing luminaires that were used in the areas affected by the construction, and return all used lamps to the Owner.

E. As specified in other sections of the Contract Documents.

3.10 DEMONSTRATION AND TRAINING

A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections.

3.11 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Grounding electrodes.
   2. Grounding electrode conductors.
   3. Equipment grounding conductors.
   4. Main bonding jumper.
   5. Ground connections.
   6. General requirements for grounding.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16950 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950, shall be:
   1. 5 ohms or less for industrial systems.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. FCI Burndy.
   2. Thomas & Betts.

B. Exothermic connectors: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Burndy Weld.

C. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Conex.

D. Ground cable: One of the following or equal:
   1. Nehring.
   2. Harger.
   3. Southwire.

E. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. In accordance with UL 467.
   4. Sectional type joined by threaded copper alloy couplings.
   5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
   1. Requirements:
      a. Soft drawn (annealed).
      b. Concentric lay, coarse stranded in accordance with ASTM B 8.
      c. Bare copper in accordance with ASTM B 3.
   2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression connectors (Above Ground):
   1. Manufactured of high copper alloy specifically for the particular grounding application.

2. Suitable for direct burial in earth and concrete.
3. Identifying compression die number inscription to be impressed on compression fitting.

D. Exothermic welds (Underground):
1. Current carrying capacity equal to that of the conductor.
2. Permanent molecular bond that cannot loosen or corrode over time.
3. Will not deteriorate with age.

E. Equipment grounding conductors:
1. Conductors shall be the same type and insulation as the load circuit conductors:
a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
2. Minimum size in accordance with the NEC.

F. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.

G. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Precast ground well boxes:
1. Minimum 10 inch interior diameter.
2. Traffic-rated cast iron cover.
3. Permanent “GROUND” marking on cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
   1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
   2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Grounding at service (600 V or Less):
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

J. Ground connections:
   1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors (Above Ground), and exothermic welds (Underground) as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
   3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

K. Grounding electrode system:
   1. Ground ring:
      a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
      b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
      c. Minimum burial depth 36 inches or as indicated on the Drawings.
      d. Re-compact disturbed soils to original density in 6-inch lifts.
   2. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
   3. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
   4. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

L. Shield grounding:
   1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
      a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
   2. Terminate the shield drain wire on a dedicated terminal block.
   3. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
   4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

M. Antenna ground:
   1. Install individual ground rod or ground system for communication system antenna:
      a. Install a dedicated grounding electrode conductor from the antenna ground to the grounding electrode system.
      b. Do not connect any other grounds to the antenna grounding electrode conductor.
   2. Install ground rod or ground system in accordance with the radio manufacturer's requirements.

N. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.08 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01410 - Regulatory Requirements.
      c. Section 05190 - Mechanical Anchoring And Fastening To Concrete And Masonry.
      d. Section 09910 - Painting.
      e. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A 240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Conform to the requirements of the Building Code as specified in Section 01410.
   2. Demonstrate the following using generally accepted engineering methods:

a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.

3. Design loading and anchoring requirements:
   a. As indicated in the Building Code unless otherwise specified.
   b. Seismic loading requirements:
      1) Freestanding or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050.
   c. Wind loading requirements:
      1) All exterior freestanding equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050.
   d. Minimum safety factor against overturning: 1.5.
   e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

B. Performance requirements:
   1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.
      c. Manufacturer.
   2. Hardware:
      a. Materials.
      b. Manufacturer.

C. Shop drawings:
   1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
   2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.
      b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
   3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation instructions:
   1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM STARTUP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Thomas & Betts.
   2. Power-Strut.
   3. Unistrut.
   4. Cooper B-Line.
   5. Robroy.
   6. Aickinstrut.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050.

B. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A 123 or A 153.
      b. Minimum zinc coating thickness of 2.5 mils.
   2. Hardware:
      a. Electro-galvanized.
      b. In accordance with ASTM A 153.

C. Stainless steel:
   1. Supports:
      a. In accordance with ASTM A 240.
      b. ANSI Type 316 material.
   2. Hardware:
      a. ANSI Type 316 material.

D. PVC coated galvanized steel:
   1. Supports:
      a. Hot dip galvanized steel as specified in this Section.
      b. PVC coating thickness of 10 to 20 mils.
   2. Hardware:
      a. ANSI Type 316 material.

E. Fiberglass:
   1. Supports:
      a. Vinyl ester.
   2. Hardware:
      a. Polypropylene.
      b. Thermal plastic elastomer.
      c. Fiberglass reinforced plastic.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Anchor bolts:
   1. As specified in Section 05190.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish all supporting structures as specified in Section 09910.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
   1. Provide the necessary sway bracing to keep trapeze type structures from swaying.

C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
   1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.

D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
   1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
   2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
   3. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
   4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
      a. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

E. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity.
      a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

F. Raceway:
   1. Furnish all conduit racks and trapeze structures needed to support the raceway from the structure.
      a. Group conduits and position on racks to minimize crossovers.
      b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.

G. Anchoring methods:
   1. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units: Post-installed anchors as specified in Section 05190.

H. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

I. Re-coat all scratches, cuts, and drilled holes in galvanized surfaces with CRC "Zinc-It" or similar product.

J. Re-coat all drilled holes and cut surfaces on PVC-coated materials.

K. Seal all drilled holes and cut surfaces on fiberglass materials.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identifying electrical, instrumentation, and process equipment and components.
   2. Material, manufacturing and installation requirements for identification devices.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16130 - Conduits.
      d. Section 16990 - Conduit Schedule.

1.02 REFERENCES

A. As specified in Section 16050.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

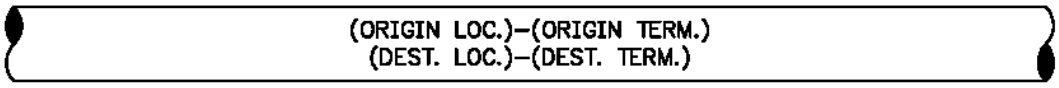
A. Nameplates:
   1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
   2. Provide all nameplates of identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.

B. Wire numbers:

1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
   a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
   b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
   c. Internal panel wires on a common terminal shall have the same wire number.
   d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
      1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130.
2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

OR

Where:



ORIGIN LOC. = Designation for originating panel or device
ORIGIN TERM. = Terminal designation at originating panel or device
DEST. LOC. = Designation for destination panel or device
DEST. TERM. = Terminal designation at destination panel or device or PLC I/O address at destination panel

   a. Identify equipment and field instruments as the origin.
   b. PCMs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
   d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
   e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
   f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the

numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):

1) Discrete Point: W:X:Y/Z
   Analog Point: W:X:Y.Z
   Where:
   W = I for input, O for output
   X = PLC number (1, 2, 3…)
   Y = Slot number (01, 02, 03…)
   Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).

3. **Case 1**: Vendor control panel (VCP) to process control module (PCM):
   Field wire number/label: A-B/C-D
   A = Vendor control panel number without hyphen (VCP#)
   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
   C = Process control module number without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   Examples: VCP#-10/PCM#-I:1:01/01
   VCP#-10/PCM#-O:1:10/07
   VCP#-10/PCM#-C0100

4. **Case 2**: Field instrument to process control module (PCM):
   Field wire number/label: E-F/C-D
   C = Process control module number without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
   E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
   F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   Examples: TIT#-2,3/PCM#-I:1:01.1
   TSH#-1/PCM#-I:2:01/00

5. **Case 3**: Motor control center (MCC) to process control module (PCM):
   Field wire number/label: G-B/C-D
   B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)
   C = Process control module without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
   G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples: MMS#-10/PCM#-I:1:01/01
MMS#-10/PCM#-O:1:10/07
MMS#-10/PCM#-C0100

6. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):
Field wire number/label: G-B/A-B
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)
G = Actual starter designation in the motor control center without hyphen (MMS#)

Example: MMS#-X2/VCP#-10

7. **Case 5**: Motor leads to a motor control center (MCC):
Field wire number/label: H-I/G-B
B = Terminal number within motor control center (manufacturer's standard terminal number)
G = Actual starter designation in the motor control center without hyphen (MMS#)
H = Equipment tag and loop number without hyphen (PMP#)
I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)

Example: PMP-#-T3/MMS#-T3

8. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
Field wire number/label: J-B/C-D
B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)
C = Process control module number without hyphen (VCP#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

Examples: MMS#-10/PCM#-I:1:01/01
MMS#-10/PCM#-O:2:10/07
MMS#-10/PCM#-C0010

9. **Case 7**: Field bus trunk segment:
Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J
C = Process control module without hyphen (PCM#).
K = Field bus cable type.
L = Field bus segment number.
M = Field Bus field network component without hyphen (PTB1) or
H = Equipment tag and loop number without hyphen (EMV#) or
J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

Examples: PCM#/PA-1A/PTB1
PTB1/PA-1B/PTB2
PCM#/DN-1A/VFD#
PCM#/DP-2A/ EMV#

10. **Case 8**: Field bus spur (drop):
    Field cable number/label: E/K-L/M
    E = Field mounted instrument tag and loop numbers without hyphen (FIT#)
    K = Field bus cable type.
    L = Field bus segment number
    M = Field bus field network component without hyphen (PTB1), identify ports on the device.

    Examples: FIT#/PA-1C/PTB1-1
    FIT#/PA-1D/PTB1-2

11. Identify all spare conductors as required for other field wires with an “S” prefix:

    Example: S MMS#-10/PCM#-C011

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Raychem.
         2) Brady.
         3) Thomas & Betts.
         4) Kroy.
   2. Non heat-shrinkable tubing:
      a. One of the following or equal:
         1) Brady.
         2) Seton.
   3. Marker printer:
      a. The following or equal:
         1) Brady.
   4. Pre-printed slip-on sleeve markers:
      a. The following or equal:
         1) Grafoplast.
         2) Engineer knows of no equal.

C. Conduit and raceway markers:
   1. One of the following or equal:
      a. Almetek: Mini Tags.
      b. Lapp Group: Maxi System.

D. Medium voltage raceway voltage labels:
   1. One of the following or equal:
      a. Brady.

b. Seton.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Nameplates:
   1. Fabricated from white-center and red face or black-center, white face laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. Two-ply.
      c. With chamfered edges.
      d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
         1) No characters smaller than 1/8-inch in height.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Machine printed black characters on white tubing.
   2. Ten point type or larger.

D. Conduit and raceway markers:
   1. Non-metallic:
      a. UV resistant holder and letters
      b. Black letters on yellow background.
      c. Minimum letter height: 1/2-inch.
      d. Adhesive labels are not acceptable.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:
   1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):

a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
   3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and cable markers:
   1. Apply all conductor and cable markers before termination.
   2. Heat-shrinkable tubing:
      a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
      b. Tubing shall be tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Conduit markings shall match the conduit schedule; as specified in single-line diagrams, panel schedules, and block diagrams.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. Where the conduit penetrates a wall or structure.
      c. Where the conduit emerges from the ground, slab, etc.
      d. The middle of conduits that are 10 feet or less in length.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach non-metallic conduit markers with nylon cable ties:
      a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
   6. Mark conduits before construction review by Engineer for punch list purposes.

7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

E. Signs and labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.
      b. Locate and mount in a manner to be clearly legible to operations personnel.
   2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc where the voltage exceeds 600 volts.
   3. Furnish and install warning signs on equipment that has more than one source of power.
      a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
   4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
      a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16123

600 VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600 volt class wire and cable.
   2. Instrumentation class wire and cable.
   3. Network cable.
   4. Fire alarm wire and cable.
   5. Telephone wire and cable.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16060 - Grounding and Bonding.
      d. Section 16075 - Electrical Identification.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B 8 - Standard Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. CSA International (CSA).

D. Insulated Cable Engineers Association (ICEA):
   1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

F. National Fire Protection Association (NFPA):

1. 70 - National Electrical Code (NEC).
2. 72 - National Fire Alarm and Signaling Code.
3. 101 - Life Safety Code.

G. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.

H. Underwriter's Laboratories Inc., (UL):
1. 44 - Thermoset-Insulated Wires and Cables.
2. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
3. 1569 - Standard for Metal-Clad Cables.
4. 2196 - Standard for Tests for Fire Resistive Cables.
5. 2225 - Standard for Cables and Cable-Fittings For Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Definitions of terms and other electrical considerations as set forth in the:
1. ASTM.
2. ICEA.

C. NEMA:
1. Type 4 enclosure in accordance with NEMA 250.
2. Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
1. Manufacturer of wire and cable.
2. Insulation:
a. Type.
b. Voltage class.
3. American wire gauge (AWG) size.
4. Conductor material.
5. Pulling compounds.

C. Shop drawings:
1. Show splice locations.

D. Test reports:
1. Submit test reports for meg-ohm tests.

E. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
      a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
      b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER`S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. 600 volt class wire and cable:
      a. General Cable.
      b. Okonite Company.
      c. Southwire Company.

2. Instrumentation class wire and cable:
    a. Alpha Wire Company.
    b. Belden CDT.
    c. General Cable BICC Brand.
    d. Okonite Company.
    e. Rockbestos Surprenant Cable Corporation.
3. Network cables:
    a. Belden CDT.
    b. General Cable.
    c. CommScope.
4. Fire alarm wire and cable:
    a. West Penn Wire.
    b. Olympic Wire and Cable.
    c. Rockbestos Surprenant Cable Corporation.
    d. Draka Lifeline.
5. Telephone wire and cable:
    a. American Telephone and Telegraph.
    b. West Penn Wire.
    c. Olympic Wire and Cable.
    d. Superior Essex Inc.
    e. Draka Comteq.
    f. General Cable.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
    1. Copper in accordance with ASTM B 3.

2.04 MANUFACTURED UNITS

A. General:
    1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
    2. Permanently mark each wire and cable with the following at 24-inch intervals:
        a. AWG size.
        b. Voltage rating.
        c. Insulation type.
        d. UL symbol.
        e. Month and year of manufacture.
        f. Manufacturer's name.
    3. Identify and mark wire and cable as specified in Section 16075:
        a. Use integral color insulation for Number 2 AWG and smaller wire.
        b. Wrap colored tape around cable larger than Number 2 AWG.

B. 600 volt class wire and cable:
    1. Provide AWG or kcmil sizes as indicated on the Drawings:
        a. When not indicated on the Drawings, size wire as follows:
            1) In accordance with the NEC:
                a) Use 75 degree Celsius ampacity ratings.

b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
2) Provide Number 12 AWG minimum for power conductors.
3) Provide Number 14 AWG minimum for control conductors.
2. Provide Class B stranding in accordance with ASTM B 8:
a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
a. XHHW-2.
b. 90 degrees Celsius rating.
4. Multiconductor cables: Not Used.

C. Instrumentation class cable:
1. Type TC.
2. Suitable for use in wet locations.
3. Voltage rating: 600 volts.
4. Temperature rating:
a. 90 degrees Celsius rating in dry locations.
b. 75 degrees Celsius rating in wet locations.
5. Conductors:
a. Insulation:
1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
b. Number 16 AWG stranded and tinned.
c. Color code:
1) Pair: Black and white.
2) Triad: Black, white and red.
3) Multiple pairs or triads:
a) Color-coded and numbered.
6. Drain wire:
a. 18 AWG.
b. Stranded, tinned.
7. Jacket:
a. Flame retardant, moisture and sunlight resistant PVC.
b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
a. Individual pair/triad:
1) Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
b. Multiple pair or triad shielding: Not Used.
c. All shielding to be in contact with the drain wire.

D. Network cables:
1. Category 6:
a. General:
1) Provide all Cat 6 cables meeting the standards set by TIA/EIA-568-C.2.
b. Conductors:
1) 24 AWG solid bare copper conductors.
c. Insulation:
1) Polyolefin.
2) 4 non-bonded twisted pair cables formed into a cable core.
d. Color code:

1) Pair 1: White/blue stripe and blue.
2) Pair 2: White/orange stripe and orange.
3) Pair 3: White/green stripe and green.
4) Pair 4: White/brown stripe and brown.

e. Outer jacket:
1) PVC with ripcord.

f. Electrical characteristics:
1) Frequency range: 0.772-100 MHz.
2) Attenuation: 32.1 dB/100 m.
3) Near-end crosstalk (NEXT): 39.3 dB.
4) Power sum NEXT: 37.3 dB.
5) Attenuation to crosstalk ratio (ACR): 7.2 dB.
6) Power sum attenuation to crosstalk ratio (PSACR): 5.3 dB/100 m.
7) Equal level far-end crosstalk (ELFEXT): 22.8 dB.
8) Power sum ELFEXT: 19.8 dB/100 m.
9) Return loss: 17.3 dB.
10) Propagation delay: 537 ns/100 m.
11) Delay skew: 45 ns/100 m.
12) Propagation delay (skew), max: 2.5 ns/100 m.

g. Four-wire:
1) Shielded twisted 2 pair.
2) Tinned, copper conductors minimum with 7 by 30 stranding.
3) AWG #22.
4) Insulation:
a) FHDPE: Foam high-density polyethylene.
b) 300-volt insulation level.
5) Outer shield:
a) 100 percent coverage.
b) Tape/braid.
c) Aluminum foil-polyester tape.
d) Tinned copper braid.
6) Outer shield drain wire:
a) Tinned, copper conductor minimum with 7 by 30 stranding.
b) AWG #22.
7) Outer jacket PVC: Polyvinyl Chloride.
a) Sunlight resistant.
8) UL/CSA flame tested.
9) Minimum bending radius 3.6 inches.
10) Nominal OD 0.356 inch.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Wire ties:
1. One of the following or equal:
a. T&B "Ty-Rap" cable ties.
b. Panduit cable ties.

B. Wire markers:

1. As specified in Section 16075.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Phase C - Blue.
      d. Single phase system - Black for one hot leg, red for the other.
      e. Neutral - White.
      f. High phase or wild leg - Orange.
      g. Equipment ground - Green.
   3. The following color code shall be followed for all 480/277 volt systems:
      a. Phase A - Brown.
      b. Phase B - Orange.
      c. Phase C - Yellow.
      d. Neutral - Gray.
      e. Equipment ground - Green.
   4. The following color code shall be followed for all 120 VAC control wiring:
      a. Power - Red.
      b. Neutral - White.
   5. The following color code shall be followed for all general purpose DC control circuits:
      a. Grounded conductors - White with blue stripe.
      b. Ungrounded conductors - Blue.
   6. Switch legs shall be violet. Three-way switch runners shall be pink.
   7. Wires in intrinsically safe circuits shall be light blue.
   8. Wire colors shall be implemented in the following methods:

a. Wires manufactured of the desired color.
b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
1. Install wires only in approved raceways.
2. Do not install wire:
a. In incomplete conduit runs.
b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits:
1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
a. Ideal Products.
b. Polywater Products.
c. 3M Products.
d. Greenlee Products.
e. Or equal as recommended by cable manufacturer.
f. Do not use oil, grease, or similar substances.

E. Cable pulling:
1. Prevent mechanical damage to conductors during installation.
2. For cables Number 1 AWG and smaller, install cables by hand.
3. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
a. Make splices in manholes or pull boxes only.
b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
1. Do not lace wires in gutter or panel channel.
2. Install all wire ties with a flush cutting wire tie installation tool:
a. Use a tool with an adjustable tension setting.
3. Do not leave sharp edges on wire ties.

I. Terminate solid conductors at equipment terminal screws with the conductor tightly wound around the screw so that it does not protrude beyond the screw head:
   1. Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.
   2. Do not use crimp lugs on solid wire.

J. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
   1. Use ring type lugs if box lugs are not available on the equipment.

K. Splices:
   1. Provide continuous circuits from origin to termination whenever possible:
      a. Obtain Engineer's approval prior to making any splices.
   2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
   3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
      a. Splice box NEMA rating requirements as specified in Section 16050.
      b. Make splices in labeled junction boxes for power conductors.
      c. Make splices for control and instrument conductors in terminal boxes:
         1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
   4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
   5. Clearly label junction and terminal boxes containing splices with the word "SPLICE."
   6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
   7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
      a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
   8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
      a) A heat shrink insulating system listed for submersible applications.
      b) Or an epoxy resin splicing kit.

L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.

M. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
   3. Shield grounding requirements as specified in Section 16060.

N. Signal cable:

1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

O. Submersible cable in wet wells:
   1. Provide Kellem's grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

P. Wiring allowances:
   1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
   2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Grounding:
   1. As specified in Section 16060.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. **As specified in Section 16050.**

3.12 SCHEDULES (NOT USED)

3.13 ADDITIONAL CONDUCTOR

A. Furnish and install 5,000 feet of #10 spare conductors in addition to whatever else conductors are indicated elsewhere. These spare conductors shall be used only when directed by the Engineer. Assume:
   1. Multiple sets of conductors runs furnished and installed at different times at separate locations

2. Each run up to 12 feet above finished floor
3. Each run to have a distance of 100 feet and two sets of terminations at each end
4. Each run being a single circuit having three conductors

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Nonmetallic conduits.
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16070 - Hangers and Supports.
      d. Section 16075 - Electrical Identification.
      e. Section 16133 - Duct Banks.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI):
   1. C80.1 - Electrical Rigid Steel Conduit.
   2. C80.3 - Steel Electrical Metallic Tubing.
   3. C80.5 - Electrical Rigid Aluminum Conduit.
   4. C80.6 - Electrical Intermediate Metal Conduit.

C. National Electrical Manufacturer's Association (NEMA):
   1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
   2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
   3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
   5. TC13 - Electrical Nonmetallic Tubing.
   6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

D. Underwriters Laboratories (UL):
   1. 1 - Standard for Flexible Metal Conduit.
   2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
   3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
   4. 360 - Standard for Liquid-Tight Flexible Steel Conduit.
   5. 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
   6. 651B - Standard for Continuous Length HDPE Conduit.
   7. 797 - Standard for Electrical Metallic Tubing - Steel.
   8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
   9. 1653 - Standard for Electrical Nonmetallic Tubing.
   10. 1660 - Standard for Liquid-Tight Flexible Nonmetallic Conduit.
   11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions and abbreviations:
   1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to: shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that serves primarily a mechanical purpose. Includes, but not limited to: bushings, locknuts, hubs, couplings, reducers, etc.
   3. GRC: Galvanized rigid steel conduit.
   4. PCS: PVC coated rigid steel conduit.
   5. PCA: PVC coated rigid aluminum conduit.
   6. IMC: Intermediate metallic conduit.
   7. EMT: Electrical metallic tubing.
   8. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   9. HDPE: High density polyethylene conduit.
   10. SLT: Sealtight – liquid-tight flexible conduit.
   11. EFLX: Explosionproof flexible conduit.
   12. FLX: Flexible metallic conduit.
   13. NFC: Nonmetallic flexible conduit.
   14. ENT: Electrical nonmetallic tubing.
   15. RAC: Rigid aluminum conduit.
   16. FRD: Fiberglass reinforced duct.
   17. NPT: National pipe thread.

1.04 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
   3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Certifications:
   1. Furnish PVC-coated conduit manufacturer's certification for each installer.

D. Record Documents:
   1. Incorporate all changes in conduit routing on electrical plan drawings.
   2. Dimension underground and concealed conduits from building lines.
   3. Furnish hard copy drawings and electronic files in AutoCAD format Version: 2004.

E. Installation drawings: Installation drawings, including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PCA or PCS conduits shall be certified by the manufacturer for installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Do not expose type PVC, FRD, NFC and ENT to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
   2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.
      c. Wheatland Tube Co.

B. Polyvinyl chloride coated rigid steel conduit:
   1. One of the following or equal:
      a. Robroy Industries.
      b. Ocal, Inc.

C. Flexible metallic conduit:
   1. One of the following or equal:
      a. AFC Cable Systems.
      b. Southwire.
      c. Electri-flex Company.

D. Flexible nonmetallic conduit:
   1. One of the following or equal:
      a. Electriflex.
      b. Carlon.
      c. Anaconda.
      d. Liquatite.

E. Sealtight liquid-tight flexible conduit:
   1. One of the following or equal:
      a. Southwire.
      b. AFC Cable Systems.
      c. Electriflex.
      d. Anaconda.

F. Rigid nonmetallic polyvinyl chloride conduit:
   1. One of the following or equal:
      a. Carlon.

b. Cantex.
c. Triangle Conduit and Cable.

G. Conduit bodies:
1. One of the following or equal:
a. Crouse-Hinds.
b. Appleton.
c. O-Z / Gedney.
d. Ocal.
e. Robroy.
f. Carlon.

H. Galvanized rigid steel conduit expansion fittings:
1. One of the following or equal:
a. Crouse-Hinds.
b. Appleton.
c. O-Z / Gedney.

I. Conduit sleeve:
1. One of the following or equal:
a. Crouse-Hinds.
b. Appleton.
c. O-Z / Gedney.

J. Conduit hangers and supports:
1. As specified in Section 16070.

K. Conduit through wall and floor seals:
1. The following or equal:
a. O-Z/Gedney:
1) Type "WSK".
2) Type “CSM”.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. GRC:
1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
a. Running conduit threads are not acceptable.
2. Hot-dip galvanized inside and out:
a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
a. UL-6.
b. ANSI C80.1.

B. PCS:
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory bonded PVC jacket:
      a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.
      c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.
      d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduit having areas with thin or no coating are not acceptable.
      c. All threads shall be coated with urethane.
   5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS conduit bodies and fittings:
      a. Malleable iron.
      b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
      c. The PVC coating on the outside of conduit bodies shall be 0.040 inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
      d. 0.002 inch interior urethane coating.
      e. Utilize the PVC coating as an integral part of the gasket design.
      f. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.
      g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
         1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
         2) The sleeve shall provide a vapor and moisture tight seal at every connection.
         3)

C. SLT:
   1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
      a. General purpose:
         1) Temperature range -20 degrees Celsius to +80 degrees Celsius.
      b. Oil resistant:
         1) Temperature range -20 degrees Celsius to +60 degrees Celsius.
   2. Sunlight resistant, weatherproof, and watertight.

3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall polyvinyl chloride jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

D. PVC:
1. Extruded from virgin polyvinyl chloride compound:
   a. Schedule 40 unless otherwise specified.
   b. Schedule 80 extra heavy wall where specified.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

E. Conduit bodies:
1. Material consistent with conduit type:
   a. Malleable iron bodies and covers when used with type GRC conduit.
   b. Cast aluminum bodies and covers when used with type RAC.
   c. PVC bodies and covers when used with type PVC.
   d. PVC-coated malleable iron bodies and covers when used with type PCS.
   e. PVC-coated copper-free cast aluminum bodies and covers when used with type PCA.
   f. Malleable iron or aluminum bodies with pressed steel or aluminum covers when used with EMT conduit.
2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
   a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.07 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
1. Construction:
   a. Malleable iron or zinc plated steel when used with steel conduit.
   b. Aluminum when used with aluminum conduit.
   c. Positive metallic conduit end stop.
   d. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
   e. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
1. Construction:
   a. Malleable iron or steel, zinc plated, with a positive metallic end stop.

b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
c. Tin plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
1. Construction:
a. Malleable iron for use with steel conduit.
b. Aluminum for use with aluminum conduit.
c. Concrete tight, 3-piece construction.
d. Rated for Class I Division 1 Group D in hazardous areas.

E. SLT fittings:
1. Construction:
a. Malleable iron.
b. Furnished with locknut and sealing ring.
c. Liquid-tight, rain-tight, oil-tight.
d. Insulated throat.
e. Furnish as straight, 45-degree elbows and 90-degree elbows.
f. Designed to prevent sleeving:
1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled over edges for sizes under 5 inches.
h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture resistant/oil resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
2. Corrosion resistant and outdoor SLT fittings:
a. Construction:
1) PVC-coated liquid-tight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
2) Insulated throat and an integral sealing ring.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
1. Construction:
a. Insulated throat.
b. PVC coated when used in corrosive areas.
c. Bonding locknut.
d. Recessed neoprene O-ring to assure watertight and dust-tight connector.
e. One half (1/2)-inch through 1-1/4-inch steel zinc electroplated.
f. One and one half (1-1/2)-inch through 6-inch malleable iron zinc plated.
g. Aluminum with aluminum conduit.
2. Usage:
a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. PVC fittings:
   1. Shall include the following:
      a. Couplings.
      b. Terminal adapters.
      c. Female adapters.
      d. Caps.
      e. Reducer bushings.
      f. Duct couplings.
      g. End bells.
      h. Expansion couplings.
      i. Duct couplings 5 degree.
      j. C - pull fittings.
      k. E - pull fittings.
      l. LB - pull fittings.
      m. LL - pull fittings.
      n. LR - pull fittings.
      o. T - pull fittings.
      p. X - pull fittings.
      q. Service entrance caps.
   2. Materials:
      a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
      b. All metal hardware shall be stainless steel.

H. Through wall and floor seals:
   1. Materials:
      a. Body: casting of malleable or ductile iron with a hot-dip galvanized finish.
      b. Grommet: neoprene.
      c. Pressure rings: PVC coated steel.
      d. Disc material: PVC coated steel.

I. Expansion/deflection couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends that they connect.
   2. Shall allow movement of 3/4 inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings: Bronze or galvanized ductile iron.
      b. Sleeve: Neoprene.
      c. Bands: Stainless steel.
      d. Bonding jumper: Tinned copper braid.

J. Expansion couplings:
   1. Shall allow for expansion and contraction of conduit:
      a. Permitting 8-inch movement, 4 inches in either direction.
   2. Constructed to maintain electrical continuity of the conduit system.
   3. Materials:
      a. Head: Malleable or ductile iron.
      b. Sleeve: Steel.
      c. Insulating bushing: Phenolic.

d. Finish: Hot-dip galvanized.
e. Aluminum when used with conduit type RAC.

K. Conduit markers:
1. As specified in Section 16075.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 16050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
1. Conduit routing:
a. The Electrical Drawings are diagrammatic in nature:
1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
b) Make changes in conduit routing due to the relocation of equipment.
3) The Electrical Drawings do not indicate all required junction boxes and pull boxes:
a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
(1) To meet cable manufacturer's pulling tension requirements.
(2) To limit total conduit bends between pull locations.
b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
1) The Engineer is the sole source in determining whether the change is constituted as a deviation:

2) Perform any changes resulting in additional conduits, or extra work from such deviations.
3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
   a. Clearances of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
   b. Clearances of 12 inches from surfaces greater than 149 degrees Fahrenheit.
   c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.
   d. Where it is necessary to route conduit close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
   a. Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1 inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduit exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route all exposed conduit to preserve headroom, access space and work space and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment removal hatches.
   b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.
9. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables, etc.
10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
11. Install conduit through wall and floor seals where indicated on the Drawings.
12. For existing and new 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:
    a. Remove and replace conduits through which mandrel will not pass.
13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
14. Install complete conduit systems before conductors are installed.

15. Provide metallic conduits terminating in transformer, switchgear, motor control center or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
16. Underground and embedded conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 16133.
    b. Make underground conduit size transitions at pullboxes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and pullboxes.

C. Lighting and receptacle conduits:
1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
    a. Minimum conduit size:
        1) 3/4 inch for exposed conduits.
        2) 1 inch for underground or in slab conduits.
2. Provide conduit materials for the installed location as specified in Section 16050.

D. Conduit usage:
1. Exposed conduits:
    a. Rigid conduit:
        1) Install the rigid conduit type for each location as specified in Section 16050.
        2) Minimum size: 3/4-inch.
    b. Flexible conduit:
        1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing:
            a) Use type SLT with rigid metallic conduit.
        2) Minimum size: 3/4-inch:
            a) 1/2 when required for connection to instruments.
        3) Maximum length:

Conduit Trade Size	Flexible Conduit Length (in)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

2. Concrete encased and embedded conduits:
    a. Type PVC coated rigid metallic conduit as specified below:
        1) Use Type PCS in underground and embedded installation as follows:

a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
b) Entering and exiting underground or embedded conduit runs a minimum 6 inches above and below grade or finished floor.
c) For any and all bends where the total deflection is greater than 45 degrees.

b. Minimum size:
1) 2 inches in duct banks unless otherwise indicated on the Drawings.
2) 1 inch for in slab conduits unless otherwise indicated on the Drawings.

3. Direct buried and sand bedded ductbank conduits:
a. Type PVC**.**
b. Minimum size: 1 inch.

4. PVC coated rigid metallic conduit:
a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.

5. GRC:
a. Conduit shall be cut square and reamed before threading.

6. PVC:
a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.
1) Use a locknut on the inside of the box to tighten the adapter to the box.
c. Route conduit to afford it the maximum physical protection.
1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.
a) Use Schedule 80 where exposed runs may be subject to physical damage.

E. Conduit joints and bends:
1. General:
a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA Type 4 or NEMA Type 4X locations, make joints liquid-tight.
b. Keep bends and offsets in conduit runs to an absolute minimum.
c. All bends shall be symmetrical.
d. The following conduit systems shall use large radius sweep elbows:
1) Underground conduits.
2) Conduits containing medium voltage cables.
3) Conduits containing shielded cables.
4) Conduits containing fiber optic cables.
e. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.
f. Make field bends with a radius of not less than the requirements found in the NEC:
1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:

a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
b) For the serving utilities, make bends to meet their requirements.

g. Replace all deformed, flattened, or kinked conduit.

2. Threaded conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar” or CRC “Zinc It.”
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Use KOPR-Shield as manufactured by T&B on threads of ferrous conduit**.**
      2) Apply to the male threads and tighten joints securely.
      3) Clean excess sealant from exposed threads after assembly.
   f. Securely tighten all threaded connections.
   g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to assure full inside diameter at all bends:
      1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

F. Conduit sealing and drainage:
   1. Conduit drainage and sealing other than required for hazardous and classified areas:
      a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enter buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
      b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.
      c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
         1) Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.
      d. Provide conduit seals similar to O/Z Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
      e. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, or equal.

2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of conduit.

G. Conduit supports:
   1. General:
      a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
         1) As specified in Section 16070.
         2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050.
      b. Support conduit at the intervals required by the NEC.
      c. Perforated strap and plumbers tape are not acceptable for conduit supports.
   2. Above suspended ceilings:
      a. Support conduit on or from the structure, do not support conduit from hanging wires or suspended ceiling grid.
   3. Concealed conduit on wood:
      a. Use 2-hole galvanized steel straps screwed or nailed to the wood or hammer-driven stamped galvanized type supports having serrated or sawtooth edges on the driven portion and designed specifically for the size and type of conduit being supported. Drive these latter supports so that the conduit is tightly and rigidly supported. Replace any dented or damaged conduit.
   4. In steel stud construction:
      a. Tie conduit at maximum 4-foot intervals with No. 16 gauge double annealed galvanized wire or conduit clips so that conduit cannot move from vibration or other causes.
   5. Conduit on concrete or masonry:
      a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      b. Use preset inserts in concrete when possible.
      c. Use pipe spacers (clamp backs) in wet locations.
      d. On plaster or stucco, use 1-hole malleable iron straps with toggle bolts.
   6. Conduit on metal decking:
      a. Use 1-hole malleable iron straps with 1-inch long cadmium-plated Type A panhead sheet metal screws. Fully or partially hammer-driven screws are not acceptable.
   7. Suspended conduit:
      a. Use malleable iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
      b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
   8. Supports at structural steel members:
      a. Use beam clamps.
      b. Drilling or welding may be used only as specified or with approval of the Engineer.
   9. PVC conduit supports:

a. Mount all conduit with hangers specifically designed for use with PVC to minimize the problems of bowing resulting from the expansion and contraction of conduit caused by varying temperatures:
1) Hangers to be constructed of PVC incorporating serrated teeth to grip the conduit securely and yet allow for conduit movement due to thermal considerations:
2) As manufactured by: Carlon E978D, E, F, G, H, and J.

10. PCS, PCA systems:
a. Provide right angle beam clamps and U bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC encapsulated nuts that cover the exposed portions of the threads.
b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps .

H. Expansion or expansion/deflection fittings:
1. General:
a. Align expansion coupling with the conduit run to prevent binding.
b. Follow manufacturer's instructions to set the piston opening.
c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
d. Furnish fittings of the same material as the conduit system.
2. For metallic conduit (PCS, PCA, GRC and RAC) provide expansion or expansion/deflection couplings, as appropriate, where:
a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.
b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

I. Empty conduits:
1. Provide a polyethylene rope rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.
2. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation:
a. Keep ends sealed until immediately before pulling conductors.

J. Miscellaneous:
1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
a. Running threads and threadless couplings are not allowed.
3. Replace any conduit installed that the Engineer determines does not meet the requirements of this Specification.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

3.13 ADDITIONAL CONDUITS

A. Furnish and install spare 1,000 feet of 1-inch Galvanized rigid steel conduits in addition to whatever else conduits are indicated elsewhere. These spare conduits shall be used only when directed by the Engineer. Assume:
   1. Multiple sets of conduit runs furnished and installed at different times at separate locations
   2. Each run up to 12 feet above finished floor
   3. Each run to have a distance of 100 feet per typical details EM102
   4. Each run to have 3 bends and 3 tee condulets and terminations fittings
   5. Each run to have two 6 by 6 by 4 inch NEMA 12 boxes and terminations fittings

B. Furnish and install spare 1,000 feet of 1-inch PVC conduits in addition to whatever else conduits are indicated elsewhere. These spare conduits shall be used only when directed by the Engineer. Assume:
   1. Multiple sets of conduit runs furnished and installed at different times at separate locations
   2. Each run installed per typical details
   3. Each run to have a distance of 100 feet
   4. Each run to have 3 bends and two stub ups per typical details

END OF SECTION

SECTION 16133

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct spacing and terminations.
   3. Steel reinforcing of concrete.
   4. Excavation and patching.
   5. Coordination with other underground utilities.
   6. Concrete.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 02318 - Trenching.
      c. Section 03200 - Concrete Reinforcing.
      d. Section 03300 - Cast-In-Place Concrete.
      e. Section 16050 - Common Work Results for Electrical.
      f. Section 16130 - Conduits.

1.02 REFERENCES

A. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Provide applicable submittal documents as specified in:
   1. Section 02318.
   2. Section 03200.
   3. Section 03300.

D. Shop drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Conduit spacers:
   1. One of the following or equal:
      a. Carlon Snap-Loc.
      b. Cantex.
      c. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Company.
      b. Pro-Line Safety Products.
      c. Panduit.

C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in Section 16130:
   1. Use duct suitable for use with 90-degree Celsius rated conductors.

B. Provide reinforcing steel as specified in Section 03200:
   1. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

A. Conduit spacers:
   1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   6. Molded-in rebar holder.
   7. Accommodates 2-inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
   1. Minimum 1/4-inch wide, flat design.
   2. Polyester.

3. Minimum pulling strength 1,200 pounds.

C. Detectable marking tape:
   1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
   2. Aluminum core laminated between polyethylene film.
   3. Six-inch wide red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES."

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

A. Concrete mix requirements as specified in Section 03300**.**

B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Duct banks:
   1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
   3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
   4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system .
   5. Install underground ducts to be self-draining:
      a. Slope duct banks away from buildings to manholes and pull boxes.

b. Slope duct banks uniformly from manholes and pull boxes to manholes and pull boxes or both ways from high points between manholes and pull boxes.
c. Slope a minimum of 1/4 inch per 10 feet.

6. Where new duct banks join to existing manholes and pull boxes make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
7. Install pull line in spare conduits:
   a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
   b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
1. Perform trenching as specified in Section 02318**.**
2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
3. Whenever possible, use the walls of the trench as forms for concrete encasement:
   a. Forms are required where the soil is not self-supporting.
4. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 1.5 inches:
   a. Separate medium voltage ducts a minimum of 7.5 inches on center.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
   a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
      1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
         a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
   a. Locate spacer in the tangent, free of the coupling on fabricated bends.
   b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
4. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope**.**

F. Concrete:
1. Install concrete as specified in Section 03300.

2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
    a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand pudding, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

H. For conduit installations beneath building slabs:
1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:
    a. Concrete for encasement under building slabs need not be colored red.
    b. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 6inches below the footer.
    c. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.
    d. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

I. Restore all surfaces to their original condition as specified in Section 02952, unless otherwise specified.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. A 47 - Standard Specification for Ferritic Malleable Iron Castings.
   2. D 149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   3. D 495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
   4. D 570 - Standard Test Method for Water Absorption of Plastics.
   5. D 648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
   6. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   7. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

C. Joint Industry Conference (JIC).

D. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes and conduit bodies as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.
   5. Catalog cut sheets.
   6. Installation instructions.

C. Shop drawings:
   1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Regulatory requirements:
   1. Outlet boxes shall comply with all applicable standards of:
      a. JIC.
      b. NEC.
      c. NEMA.
      d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. As specified in Section 16050.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Pressed steel boxes:
      a. Steel City.
      b. Appleton.
      c. Crouse - Hinds.
      d. Thomas & Betts.
   2. Plastic and/or fiberglass boxes:
      a. Hoffman.
      b. Carlon.
      c. Stahlin.
   3. Plastic coated steel boxes:
      a. Rob Roy.
      b. OCAL.
   4. Cast device boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. OZ/Gedney.
   5. Formed steel enclosures:
      a. Hoffman.
      b. Thomas and Betts.
      c. Stahlin.
      d. Rittal.
   6. Stainless steel enclosures:
      a. Hoffman.

b. Stahlin.
c. Rittal.

7. Pressed steel boxes and concrete boxes:
   a. Appleton.
   b. Steel City.
   c. Cooper/Crouse Hinds.
   d. OZ Gedney.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Pressed steel boxes:
   1. One-piece galvanized pressed steel.
   2. Knockout type boxes.
   3. Minimum size 4-inch square by 2-1/8-inch deep.

B. Concrete boxes:
   1. For outlets and pull boxes in concrete construction.
   2. Pressed steel or cast construction, concrete tight.
   3. Knockout sizes range from 1/2 inch to 1 inch.
   4. Depth as needed.
   5. Types:
      a. Four-inch octagon.
      b. Four-inch octagon ceiling boxes with hanging bars.
      c. Gangable masonry boxes:
         1) 3-1/2-inch deep, 3-3/4-inch high, length as required:
            a) 2-1/2-inch deep boxes may be used where wall thickness precludes the use of the deeper boxes.
         2) With partitions as needed.

C. Threaded-hub boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.
   2. Aluminum (copper free) boxes:
      a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
   3. Malleable iron boxes:
      a. Conforming to ASTM A 47 Grade 32510.

D. Plastic coated threaded-hub boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.

e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
g. With pressure sealing sleeve to protect the connection with conduit.

E. Fiberglass boxes:
1. NEMA Type 4X.
2. Constructed of molded fiberglass reinforced polyester.
3. Integral neoprene gasket on cover attached with an oil-resistant adhesive.
4. Enclosures to have internal pads for mounting optional panels and terminal kits.
5. Covers:
a. Screw cover enclosures:
1) Covers held in place with captive, stainless steel, or monel screws.
2) Covers attached to body with internal zinc-plated steel hinges.
b. Quick release latches covers:
1) Corrosion resistant fiberglass hinges.
2) Spring loaded fiberglass latches with a monel or stainless steel bail attached with monel or stainless steel screws.
3) With a Type 316 stainless steel padlock hasp.
6. With external mounting feet.
7. Meeting the following minimum standards and tests:

Physical Property	Value	ASTM Method
Flexural strength	12,000 psi	D 790
Heat distortion	400° Fahrenheit	D 648
Water absorption (24 hrs)	0.5 percent	D 570
Tensile strength	5000 psi	D 651
Specific gravity	1.8	D 792
Flammability	94V-0	UL 94
Dielectric strength	4000 V.P.M.	D 149
Arc resistance	180 second	D 495

F. Formed steel enclosures:
1. Steel:
a. NEMA Type 12.
b. Fabricated from 14-gauge steel, minimum.
c. All seams continuously welded ground smooth.
d. Door:
1) Rolled lip around 3 sides.
2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
1) Attached with an adhesive.
2) Retained by a retaining strip.
f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
1) With a hasp and staple for padlocking.
g. Provide large enclosures with door and body stiffeners for extra rigidity.

h. No holes or knockouts.
i. Finish:
1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
2) White electrostatically applied polyester powder mounting plate.
j. Heavy gauge steel external mounting brackets when surface mounted.

2. Stainless steel:
a. NEMA Type 4X:
1) Boxes in locations subject to flooding or temporary submersion:
a) NEMA Type 6.
b. Fabricated from 14-gauge Type 316 stainless steel.
c. All seams continuously welded.
d. Door:
1) Rolled lip around 3 sides.
2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
e. Neoprene door gasket to provide a watertight seal:
1) Attached with an adhesive.
2) Retained by a retaining strip.
f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
1) With a hasp and staple for padlocking.
g. Provide large enclosures with door and body stiffeners for extra rigidity.
h. No holes or knockouts.
i. Finish:
1) Brushed.
j. Stainless steel external mounting brackets when surface mounted.

G. Cast iron junction boxes:
1. NEMA Type 4.
2. Recessed cover boxes.
3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
4. Designed for flush mounting in walls or floors:
a. Can be surface mounted using mounting lugs.
5. Construction:
a. Cast iron box.
b. Covers:
1) Checkered plate covers suitable for foot traffic.
2) When used in areas subject to vehicular traffic H-20 loading.
c. Hot dip galvanized.
d. Neoprene gasket.
e. Stainless steel screw covers.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Fasteners:
1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:

a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.
3. Steel with white polyester powder finish.

D. Floor stand kit when shown:
1. Fabricated from 12-gauge steel.
2. Bottom plate 11 gauge.
3. Heights:
a. 24 inches.
4. Do not provide external mounting brackets, when a floor stand kit is used.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. General:
1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050.
2. Provide outlet box materials to match the conduit system:
a. EMT - Pressed metal boxes.
b. GRC - Cast ferrous boxes.
c. RAC - Aluminum (copper free) boxes.
d. PCS - PVC coated cast ferrous boxes.
e. PVC - PVC boxes.
f. PCA - PVC coated aluminum boxes.
3. Solid type gang boxes:
a. For more than 2 devices.
b. For barriered outlets.
4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:

a. Use machined spacers to maintain air space; built-up washers are not acceptable.
b. Use stainless steel or nylon materials for spacers.

5. Use cast malleable iron boxes when box must support other devices.
6. Boxes serving luminaires or devices:
   a. Use as pull boxes wherever possible.
7. In finished areas:
   a. Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
8. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
9. In terminal boxes, furnish terminals as indicated on the Drawings (if not indicated on the Drawings, then furnish terminals as required), with a minimum of 50 percent spare terminals:
   a. Furnish wireways for discrete and analog/DC wiring.
   b. Separate analog wiring from 120 V discrete or power wiring.
10. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
11. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet boxes:
   1. Locate outlet boxes as indicated on the Drawings:
      a. Adjust locations so as not to conflict with structural requirements or other trades.
   2. Use deep threaded-hub malleable iron or aluminum boxes:
      a. In hazardous areas.
      b. Where exposed to the weather.
      c. In unheated areas.
      d. Where subject to mechanical damage:
         1) Defined as exposed boxes less than 10 feet above the floor.
      e. To act as a pull box for conductors in a conduit system.
      f. Accommodate wiring devices.
   3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
   4. Outlet boxes may be used as junction boxes wherever possible.

D. Pull boxes and junction boxes:
   1. Size pull boxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
   2. Install pull boxes such that access to them is not restricted.

E. For boxes not indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050.
   2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
      a. One-piece, galvanized, pressed steel.
   3. Ceiling boxes for flush mounting in concrete:
      a. Deep, galvanized, pressed steel.

4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
    a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
5. Outlet, control station, and junction boxes for installation in corrosive locations:
    a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
    b. Furnished with mounting lugs.
6. Boxes for concealed conduit system:
    a. Non-fire rated construction:
        1) Depth: To suit job conditions and comply with the NEC.
        2) For luminaries: Use outlet boxes designed for the purpose:
            a) 50 pounds or less: Box marked “For Fixture Support.”
            b) More than 50 pounds: Box listed and marked with the weight of the fixture to be supported (or support luminaire independent of the box.)
        3) For ceiling suspended fans:
            a) 35 pounds or less: Marked “Acceptable for Fan Support.”
            b) More than 35 pounds, up to 70 pounds: Marked “Acceptable for Fan Support up to 70 pounds (or support fan independent of the box).”
        4) For junction and pull boxes: Use galvanized steel boxes with flush covers.
        5) For switches, receptacles, etc:
            a) Plaster or cast-in-place concrete walls: Use 4-inch or 4-11/16-inch galvanized steel boxes with device covers.
            b) Walls other than plaster or cast-in-place concrete: Use type of galvanized steel box which will allow wall plate to cover the opening made for the installation of the box.
7. Recessed boxes in fire rated (2 hours maximum) bearing and nonbearing wood or steel stud walls (gypsum wallboard facings):
    a. Use listed single and double gang metallic outlet and switch boxes.
        1) The surface area of individual outlet or switch boxes shall not exceed 16 square inches.
    b. The aggregate surface area of the boxes shall not exceed 100 square inches per 100 square feet of wall surface.
    c. Securely fasten boxes to the studs.
        1) Verify that the opening in the wallboard facing is cut so that the clearance between the box and the wallboard does not exceed 1/8 inch.
    d. Separate boxes located on opposite sides of walls or partitions by a minimum horizontal distance of 24 inches.
        1) This minimum separation distance may be reduced when wall opening protective materials are installed according to the requirements of their classification.
    e. Use wall opening protective material in conjunction with boxes installed on opposite sides of walls or partitions of staggered stud construction in accordance with the classification requirements for the protective material.
8. Other fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

F. Recessed boxes:

1. Support recessed boxes in suspended ceilings or stud partitions with galvanized steel box hangers of types made specifically for the purpose or attach directly to wood members or blocking.
2. Secure hangers or boxes to wood with 1-inch long cadmium-plated Type A pan head screws:
    a. Fully or partially hammer-driven screws are not acceptable.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Plates.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. Federal Specifications (FS):
   1. W-C 596 - Connector, Electrical, Power, General Specification for.
   2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

C. National Electrical Manufacturers Association (NEMA):
   1. WD1 - General Color Requirements for Wiring Devices.
   2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
   3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   4. WD6 - Wiring Devices Dimensional Specifications.

D. Underwriters Laboratories Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 514D - Cover Plates for Flush-Mounted Wiring Devices.
   4. 943 - Ground-Fault Circuit-Interrupters.
   5. 1472 - Solid State Dimming Controls.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. GFCI: Ground fault circuit interrupter.
   2. P-S: Pass and Seymour.
   3. Cooper: Cooper Wiring Devices, a division of Cooper Industries.
   4. T&B: Thomas and Betts.

1.04 SYSTEM DESCRIPTION

A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.

C. Shop drawings:
   1. Engraving schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Switches:
   1. One of the following or equal:
      a. Hubbell.
      b. Leviton.
      c. Cooper.

B. Receptacles:
   1. General purpose receptacles: One of the following or equal:
      a. Hubbell.
      b. Leviton.
      c. Cooper.

C. Plates:
   1. General location: The following or equal:
      a. P-S.
      b. Cooper.
   2. Wet or corrosive areas: One of the following or equal:
      a. Hubbell.
      b. Cooper.
      c. T&B.
      d. P-S.
   3. In-use covers: One of the following or equal:
      a. TayMac.
      b. Cooper.
      c. P-S.
      d. T&B.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Switches:
   1. General:
      a. 120-277 VAC.
      b. 20 ampere.
      c. Listed in accordance with UL 20.
      d. Designed and constructed in accordance with FS W-S-896/2.
      e. Back and side wired unless otherwise indicated.
      f. Integral grounding terminal.
      g. Totally enclosed:
         1) Color-coded body with color corresponding to ampere rating.
      h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
      i. Color:
         1) Ivory in finished areas.
         2) Brown in all other areas.
   2. General purpose switches:

a. Toggle type.
3. Switches for use with photocell:
a. Maintained contact.
b. Two circuit.
c. Three position:
1) Center off.

B. Receptacles:
1. General purpose receptacles:
a. Single or duplex as indicated on the Drawings.
b. 125 VAC.
c. 20 ampere or as indicated on the Drawings.
d. NEMA Type 5-20R configuration for 20 ampere receptacles.
e. Other NEMA configurations as indicated on the Drawings.
f. Listed in accordance with UL 498.
g. Designed and constructed in accordance with FS W-C-596.
h. Back and side wired.
i. One-piece, rivet-less mounting strap.
j. Color:
1) Ivory in finished areas.
2) Brown in all other areas.
3) Orange when powered by a UPS.
2. Ground fault interrupter receptacles (GFCI):
a. 125 VAC.
b. 20 ampere.
c. Trip level 4-6 milliampere.
d. Individual and feed through protection.
e. UL 943 and UL 498 listed.
f. NEMA Type 5-20R configuration.
g. For damp or wet locations:
1) Weather resistant, in accordance with UL 498.

C. Plates:
1. General location:
a. Type 302 or 304 stainless steel.
b. Brushed satin finish.
c. Minimum thickness: 0.032 inches.
d. Rectangular or square shape.
e. Engraving:
1) Engrave each switch plate with the following:
a) Area served.
b) Circuit number.
2) Engrave each receptacle plate with the following:
a) Circuit number.
3) Treat engraving to improve visibility and, except for stainless steel plates, to prevent corrosion.
4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
f. Coordinate the number of gangs, number, and type of openings with the specific location.
2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
a. General:

1) UL listed for wet locations.
2) Gasketed.
3) Die cast metal:
a) Match material to box material.

b. Switches:
1) Lever operated:
a) Provide toggle switch.

c. Receptacles:
1) Weather proof in-use cover:
a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
b) Gasketed.
c) Lockable.
d) UL listed and in accordance with NEC.

3. Corrosive areas:
a. Neoprene.
b. Gasketed.
c. Weatherproof.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Mounting heights:
1. Process and production areas:
a. Switches and receptacles 48 inches from finished floor to top of plate.
2. Offices and finished areas:
a. Switches: 48 inches from finished floor to top of plate.
b. Receptacles: 18 inches from finished floor to center of plate.

C. Switches:
   1. Over 300 Volts:
      a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

D. Receptacles:
   1. Provide GFCI receptacles as indicated on the Drawings.
      a. Provide weather resistant GFCI receptacles in all wet or damp areas.
         1) As specified in Section 16050.
   2. Mount non-weatherproof receptacles vertically:
      a. Ground slot down.
   3. Mount weatherproof receptacles horizontally:
      a. Neutral slot up.
   4. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

E. Ensure all plates make a firm seal with wall for recessed mounted devices:
   1. Outside edges of plates parallel with building lines.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the following to the Engineer and Owner:
   1. Switching is as indicated on the Drawings.
   2. All circuits conform to the panel schedules.
   3. All ground fault receptacles operate at levels below or equal to OSHA maximum allowable fault levels.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16123 - 600 Volt or Less Wires and Cables.

1.02 REFERENCES

A. As specified in Section 16050.

B. ASTM International (ASTM):
   1. D 3005 – Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

C. CSA International (CSA):
   1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.

D. Underwriters Laboratories, Inc. (UL):
   1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to all screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturer: One of the following or equal:
         1) Thomas and Betts, Stakon.
   2. For process equipment connections work from manufacturer's drawings.

B. Joints, splices, taps, and connections:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Use only plated copper alloy connectors or lugs:
         1) Aluminum connectors or lugs are not acceptable for copper conductors.
      c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
      d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
         1) Manufacturer: One of the following or equal:
            a) Buchanan 2006S or 2011S, with 2007 or 2014 insulating caps..
      e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
         1) Manufacturer: One of the following or equal:
            a) Burndy.
            b) Thomas and Betts.
      f. Heat shrink tubing:
         1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
         2) Minimum shrink ratio: 4 to 1.
         3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
         4) Internally applied adhesive sealant.
         5) Cross-linked polyolefin:
            a) Manufacturers, one of the following or equal:
               (1) 3M ITCSN.
               (2) Thomas & Betts Shrink-Kon.
   2. Instrumentation class cable splices:
      a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
      b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
      c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
      d. Two-part mold body with tongue and groove seams and built in spacer webbing.
      e. Manufacturer: One of the following or equal:

1) 3M - Scotchcast 72-N.

C. Insulating tape:
1. General purpose insulating tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
d. Flame retardant, hot- and cold- weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600 VAC.
f. Meeting and complying with:
1) ASTM D 3005 Type I.
2) UL 510.
3) CSA C22.2.
g. Manufacturer: One of the following or equal:
1) 3M - Scotch Number Super 33+.
2. General-purpose color-coding tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.
2) Yellow.
3) Blue.
4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.
e. For use as phase identification, marking, insulating, and harnessing.
f. Meeting and complying with:
1) UL 510.
2) CSA C22.2.
g. Manufacturer: One of the following or equal:
1) 3M - Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Load connections:
   1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123.

C. Zero to 600-volt systems:
   1. Make all connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
   4. Number all power and control wires before termination.

D. Motor connections (600 volts and below):
   1. Terminate wires with compression type ring lugs at motors.
   2. Connection at both the motor leads and the machine wires shall have ring type compression lugs.
   3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by manufacturer.
   4. Wire markers shall be readable after boot installation.
   5. Manufacturer: One of the following or equal:
      a. Raychem MCK.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

APSSECTION 16210

UTILITY COORDINATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Coordination with the utility companies to provide service.
   2. Contractor's responsibilities for connecting to utilities and providing utility service to the facilities.
   3. Descriptions of utility services required.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Utility contacts:
   1. Electric utility:
      a. Name: Sandy Finley
      b. Utility: Arizona Public Service (APS)
      c. Address: 1250 E. State Route 89A,
         Cottonwood, AZ 86326
         M.S. 4718
      d. Phone number: (928)-646-8463
      e. E-mail: sandra.finley@aps.com

1.04 SYSTEM DESCRIPTION

A. Temporary electrical service:

1. Provide all Work and materials and bear all costs for providing temporary construction power and the permanent electrical service, including but not limited to:
    a. All Work and materials not provided by the electric utility.
    b. All permits and fees required by the electric utility.

B. Permanent electrical service:
1. PRE-BID COORDINATION: In addition to the minimum requirements indicated on the Contract Drawings, the CONTRACTOR shall contact APS, and investigate any additional requirements that are necessary for this project. Refer to APS's ELECTRICAL SERVICE SPECIFICATIONS in order to determine the complete scope of work prior to the Bid.
2. CONSTRUCTION PHASE COORDINATION: CONTRACTOR shall coordinate all work with APS. This coordination shall include, but is not limited to, the following:
    a. Pre-construction meeting and coordination
    b. Utility demolition work
    c. Utility cable work (primary and secondary)
    d. Utility power pole work
    e. Utility power underground work
    f. Utility transformer work
    g. Utility switch and fuse cabinet work
    h. City inspection of the service entrance section
    i. Utility company inspection
    j. Utility energization work

C. General:
1. Coordinate and obtain inspections and final installation approval from the serving utilities and other authorities having jurisdiction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Certification:
1. Submit certification that the intended installation has been coordinated with the utility companies.
2. Include a narrative description of the utility's requirements and points of connection, names and telephone numbers for contacts at the utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Materials and equipment used in performance of Electrical Work shall be listed or labeled by UL, or other equivalent recognized independent testing laboratory, for the class of service intended.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:
   1. Before start of Site Work, make arrangements for temporary telephone and electrical service as required.

B. Electrical systems:
   1. Before bidding, the electrical contractor shall contact the utilities to determine the Work and materials that will be required from the Contractor, and all fees and permits that will be required, so that all utility systems furnished by the Contractor will be included in the bid.
   2. Coordinate Work with Engineer to minimize downtime of existing operating equipment and electrical distribution systems and to preclude unsafe operation:
      a. Notify Owner 10 days before power interruptions.
      b. Coordinate downtime with Owner and local electric utility.
   3. Before commencing Work, coordinate electric service entrance requirements with local electric utility to assure that the installation will be complete as specified in these Contract Documents:
      a. Ensure power transformer size, electrical characteristics, and location are consistent with the design and service voltage provided by the electric utility coordinated with other trades.
      b. Arrange for utility revenue meter.
      c.
   4. During the construction of the Project, the existing electrical service must remain fully functional in order to supply uninterrupted electrical power to the facility and its ancillary buildings and structures.

C. Before commencing Site Work, coordinate underground conduit installations with other Work to eliminate conflicts and avoid interferences with other underground systems.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish materials in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Furnish equipment in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16222

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage motors up to 500 horsepower:
      a. Furnished separately.
      b. Part of driven equipment specified in other sections.
      c. Other electric motors required for a complete installation.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16950 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 16050.

B. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
   1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.

D. ASTM International (ASTM).
   1. B-117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

E. Institute of Electrical and Electronic Engineers (IEEE):
   1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
   3. 114 - Standard Test Procedure for Single-Phase Induction Motors.
   4. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class 1, Division 2 and Zone 2 Locations.

5. 841 - Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
6. 1349 - Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.

F. National Electrical Manufacturers' Association (NEMA):
1. MG-1 - Motors and Generators.
2. MG-2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.

G. Underwriters Laboratories Inc. (UL):
1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Submit completed motor data sheets for each motor supplied:
1. Conform to data sheet in the appendix of this Section.
2. Manufacturer’s or other data sheets are not acceptable.

C. Product data:
1. Descriptive bulletins.
2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
3. Complete electrical data.
4. Torque, current, and power factor vs. speed curves:
   a. At 100 percent rated voltage for all full voltage started and VFD driven motors.
   b. For motors on reduced voltage start at 70, 80, 90 and 100 percent rated voltage.
5. Accessories data:
   a. Power factor correction capacitors:
      1) Size in KVAR, for all motors not connected to variable frequency drives.
   b. Motor winding heaters:
      1) Voltage.
      2) Watts.
   c. Winding temperature detectors:
      1) Type.
      2) Rating.

d. Moisture detectors.
6. Mechanical data:
a. Bearing design and bearing life calculations.
b. Resonant frequencies for all VFD-driven motors 50 horsepower or greater.

D. Shop drawings:
1. Motor weight.
2. Frame size.
3. Conduit box(es), size(s), and location(s).
4. Outline drawings with dimensions.
5. Installation details for the project seismic criteria.

E. Test reports:
1. Factory test reports with test reference standard identified.

F. Certification:
1. When motors are driven by variable speed drive systems, submit certification that selected motor:
a. Is capable of satisfactory performance under the intended load.
b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
c. Is matched to the type of variable frequency drive specified.

G. Calculations:
1. Where site conditions specified in Section 16050 exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Motors 200 hp and larger:
1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following no equal:
   1. US Motors.
   2. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. 3-phase induction motors - general:
   1. Voltage:
      a. All motors 1/2 HP and larger shall be rated 460 V, 3 phase unless otherwise indicated on the Drawings.
      b. Dual voltage motors rated 230/460 V, 3 phase are acceptable provided all leads are brought to the conduit box.
   2. Motors driving identical machines shall be identical.
   3. All motors greater than 1 HP and up to 500 HP shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.
   4. Horsepower as indicated on the Drawings:
      a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
   5. Service factor:
      a. 1.15 service factor on sine wave power.
      b. 1.0 when driven by VFD.
   6. Torque:
      a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
      b. When started using reduced voltage starters:
         1) Provide motors that develop sufficient torque for acceleration to full speed.
      c. NEMA Design B except where driven load characteristics require other than normal starting torque:
         1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
   7. Enclosures:
      a. As specified in the individual equipment Specifications or in this Section.
      b. Totally enclosed fan cooled:
         1) Cast iron conduit box.

2) Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger.

c. Explosion-proof:
1) Tapped drain holes with corrosion resistant plugs for frames 286T and smaller and automatic breather and drain devices for frames 324T and larger.

d. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.

8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
9. Nameplates:
a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
1) NEMA standard motor data.
a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
2) AFBMA bearing numbers and lubrication instructions.
10. Hardware:
a. Type 316 stainless steel.
11. Conduit boxes:
a. Cast iron or stamped steel.
b. Split from top to bottom.
c. Provide gaskets at the following interfaces:
1) Frames and conduit boxes.
2) Conduit boxes and box covers.
d. Rotatable through 360 degrees in 90-degree increments.
1) Where available based on the size of the conduit box.
e. Exceeding the dimensions defined in NEMA MG-1.
f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor bearings:
a. Antifriction.
b. Regreasable and initially filled with grease for horizontal motors, vertical motors per manufacturer's standard design.
c. Bearings and lubrication suitable for ambient temperature and temperature rise.
d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.
13. Insulation systems:
a. Motors installed in ambient temperatures 40 degrees Celsius or less:
1) Provide Class F insulation.
2) Design temperature rise consistent with Class B insulation.
3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
1) Provide Class F insulation.

2) Design temperature rise consistent with Class B insulation.
3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.

c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
1) Provide Class H insulation.
2) Design temperature rise consistent with Class F insulation.
3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.

14. Motor leads:
a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.

15. Noise:
a. Maximum operating noise level in accordance with NEMA MG-1.

B. Submersible motors:
1. Enclosures:
a. Totally enclosed non-ventilated (TENV) watertight casing.
b. Inner and outer shaft seals separated by an oil chamber.

2. Cooling:
a. Suitable for continuous operation in totally, partially or nonsubmerged condition without overheating.
b. Convection cooling by the surrounding environment or pump cooling by circulating a portion of the pumped media through a cooling water jacket as recommended by the manufacturer based on horsepower and application.

3. Electrical cables:
a. Wire unit without splices. Coordinate with Contractor to ensure cables of adequate length.
b. Epoxy encapsulated cable entry into terminal box.

4. Insulation:
a. Sealed moisture resistant windings.
b. Class H.

5. Motor protection:
a. Provide temperature detection in motor windings.
b. Provide moisture detection in motor housing.
c. Other detection and protection functions specified in the in the driven equipment Section.

C. Vertical motors:
1. Enclosures:
a. Totally enclosed fan cooled (TEFC) for motors 200 horsepower and less installed outdoors.
b. Weather protected Type II (WPII) for motors greater than 200 horsepower installed outdoors.
c. Weather protected Type I (WPI) where installed indoors.

2. Thrust bearings:
a. Selected for combined rotor and driven equipment loads.
b. Coordinate with driven equipment supplier for maximum vertical thrust of driven equipment.

3. Anti-reverse ratchet.

D. Motors driven by variable frequency drives:
   1. Compatible with the variable frequency drives specified.
   2. Inverter duty rated and labeled.
   3. Meet the requirements of NEMA MG-1 Part 31.
   4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
   5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
   6. Shaft grounding ring:
      a. Provide a shaft grounding ring for each VFD driven motor.
      b. Aluminum frame and internal components.
      c. Conductive microfiber brushes.
      d. Maintenance free design.
      e. Aegis Bearing Protection ring as manufactured by Electro Static Technology or equal.

E. Motors installed in corrosive environments:
   1. Nameplate indicating conformance to IEEE 841.
   2. Stator double dipped in varnish and baked.
   3. Stator and rotor coated with corrosion resistant epoxy.
   4. Frame, brackets, fan guard and conduit box coated with minimum of 2 coats of epoxy paint.
   5. Withstand salt spray tests in accordance with ASTM B-117.
   6. Suitable for hose down areas.

F. Single phase motors:
   1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
   2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
   3. Ball bearings: Sealed.
   4. 1/2 horsepower or less fan motors:
      a. Split-phase or shaded pole type when standard for the equipment.
      b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
   5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
   6. Integral overload protection.

G. Direct current motors:
   1. Voltage as indicated on the Drawings.
   2. Provide with controller that accepts DC voltage as indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Motor winding heaters:
   1. Provide all 3 phase motors with belted or cartridge space heaters mounted within the motor enclosure as indicated on the Drawings.
   2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.

3. Power leads for heaters wired into conduit box.
4. Installed within motor enclosure adjacent to core iron.

B. Winding temperature detectors:
1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
a. Where required by the driven equipment Specification or as indicated on the Drawings.
b. RTD type, 2 per phase, 100 ohm platinum.
2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Factory testing:
1. Motors less than 250 horsepower:
a. Perform manufacturer's standard production tests including but not limited to:
1) No load current.
2) High potential test.
3) Winding resistance.
b. Furnish copies of standard test reports on prototype or identical units.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install motors in accordance with manufacturer's instructions.

C. Install shaft grounding ring on VFD driven motors in accordance with the manufacturer's instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
   1. Windings energized to 1,000 volts DC for 1 minute.
   2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
   3. Inform the Engineer of any unusual or unacceptable test results.
   4. This test is in addition to the acceptance tests in Section 16950.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

END OF SECTION

MOTOR DATA SHEET

MOTOR/ EQUIPMENT TAG _____ MOTOR NUMBER _____

SPECIFICATION NUMBER OF DRIVEN MACHINE _____

MOTOR NAMEPLATE DATA

MANUFACTURER _____ MODEL/SERIES _____ MODEL NO. _____

FRAME _____ ENCLOSURE _____ NEMA DESIGN _____

HP _____ SERVICE FACTOR _____ RPM _____

INSULATION CLASS _____ VOLTS _____ FULL LOAD AMPS _____

AMBIENT TEMP _____ PHASE _____ NO LOAD AMPS _____

DESIGN TEMP RISE _____ HERTZ _____ LOCK ROTOR AMPS _____

INRUSH CODE LETTER _____

	100% LOAD	75% LOAD	50% LOAD
GUARANTEED MINIMUM EFFICIENCIES:			
GUARANTEED MINIMUM POWER FACTOR:			

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: _____ KVAR

ACCESSORIES

MOTOR WINDING HEATER _____ VOLTS _____ WATTS

WINDING THERMAL PROTECTION

WINDING TEMP SWITCHES (YES/NO) _____

RTD:

TYPE _____ QUANTITY PER PHASE _____ # OF WIRES _____

NOMINAL RESISTANCE _____ NOMINAL TEMP _____ COEFFICIENT _____

RECOMMENDED ALARM _____ DEGREES CELSIUS RECOMMENDED TRIP _____ DEGREES CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO) _____ PART WINDING (YES/NO) _____ WYE - DELTA (YES/NO) _____

2 SPEED, 1 WINDING (YES/NO) _____ 2 SPEED, 2 WINDING (YES/NO) _____

AREA CLASSIFICATION:

CLASS _____ DIVISION _____ GROUP _____ TEMP CODE _____

* Conforms to NEMA MG-1 Part 31.

SECTION 16262

VARIABLE FREQUENCY DRIVES 11-50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Variable frequency drives (VFD) 0.5 to 50 horsepower for control of NEMA Design B squirrel cage induction motors installed in:
      a. Standalone enclosures.
      b. Motor control centers.
      c. Vendor furnished equipment.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

C. Underwriters' Laboratories (UL):
   1. 508C - Power Conversion Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. Point of common coupling: the point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the closest directly connected panelboard or motor control center bus supplying power to the VFD.

1.04 SYSTEM DESCRIPTION

A. Design requirements:

1. Each VFD system consists of all components required to meet the performance, protection, safety, testing, and certification criteria of this Section.
2. The VFD system:
    a. Is a fully integrated package.
    b. Includes all material necessary to interconnect all VFD system elements, even if shipped separately.

B. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer:
    1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
    2. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
        a. Provide equipment necessary to mitigate potential damage to motor insulation.

C. Performance:
    1. Operating envelope:
        a. Speed and torque requirements:
            1) Provide a variable torque or constant torque VFD as required by the driven load.
            2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
        b. Current requirements:
            1) Full rated current output on a continuous basis.
            2) Variable torque VFD:
                a) Minimum 110 percent current overload for 1 minute.
            3) Constant torque VFD:
                a) Minimum 150 percent current overload for 1 minute.
    2. Minimum VFD system efficiency:
        a. Ninety-six percent.
        b. VFD system efficiency shall be calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \text{ x } 100$$

Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.

    3. Total power factor:
        a. Minimum of 0.96 lagging across the entire speed range.
        b. At no speed shall the VFD have a leading power factor.
    4. Frequency accuracy:
        a. Minimum of within 0.01 percent.

5. Speed regulation:
    a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050:
1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
1. Manufacturer of the VFD.
2. Manufacturer of all components of the VFD.
3. Dimensions:
    a. Height.
    b. Width.
    c. Depth.
    d. Weight.
4. Nameplate schedule.
5. Bill of material.
6. Ratings:
    a. Voltage.
    b. Phase.
    c. Input current.
    d. Output current.
    e. Interrupting rating.
    f. Momentary current rating.
7. List of recommended spare parts.
8. Catalog cut sheets for major components.
9. Design data:
    a. Efficiency and power factor values.
    b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
    c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
    d. Certification that all electronic circuits and printed circuit boards are conformally coated.
10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section16050:
    a. Manufacturer’s statement of seismic qualification with substantiating test data.
    b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
1. Complete plan and elevation drawings showing:
    a. All dimensions.
    b. Panel, sub-panel and component layout indexed to the bill of material.
    c. Conduit connections.

2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
    a. Include terminal number and wire numbers.
4. Complete single-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
    a. Clearly indicate device electrical ratings on the drawings.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:
1. Spare parts list with supplier names and part numbers.
2. Startup and commissioning instructions and data.
3. Operating manuals:
    a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
4. Operating instructions:
    a. Written descriptions detailing the operational functions of all controls on the front panel.
5. Maintenance manual:
    a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
    b. Manuals shall include, but are not limited to the following:
        1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
        2) Detailed control instructions which outline the purpose and operation of every control device used in normal operation.
        3) All schematic wiring and external diagrams:
            a) Furnish drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.

F. Test reports.

G. Manufacturer's field reports:
   1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
   2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

H. Record Documents:
   1. Certified Record Documents of equipment with information listed above.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Qualifications:
   1. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
   2. VFD systems shall be UL 508C listed and labeled.
   3. Variable frequency drives shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program that is certified in conformance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

B. Ship the VFDs and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on site off loading equipment:
   1. VFDs shall be delivered to the site preassembled and wired.
   2. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Submit equipment for review.

B. Following approved submittal, conduct internal factory test to ensure that all systems and equipment are functional and submit certified test results for Engineer's review.

C. Conduct factory acceptance test.

D. Ship equipment to project site after successful completion of factory acceptance test.

E. Install equipment in the field.

F. Submit manufacturer's certification that all equipment has been properly installed and is fully functional for Engineer's review.

G. Conduct field acceptance test and submit results for Engineer's review.

H. Conduct Owner's training sessions.

I. Formally energize, start-up and commission equipment.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

B. The VFD manufacturer shall be responsible for start up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer and Owner.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. After startup and training has been completed, the VFDs shall be commissioned by the VFD manufacturer:
   1. The VFDs shall operate the driven load without failure under normal operating conditions for a period of 30 days.
   2. Any failures shall be repaired by the VFD manufacturer.
   3. Following repair, the commissioning period shall be restarted. Commissioning shall only be complete once an uninterrupted 30-day period has been completed.

1.15 MAINTENANCE

A. Spare parts:
   1. The following spare parts shall be furnished:
      a. One set of all power and control fuses for each VFD.
      b. One complete main control key pad for each type and rated size of VFD.
      c. One spare fan for each VFD unit.
      d. Two sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
      e. Any special dedicated tools for emergency service and troubleshooting.
      f. One set of thyristors or power electronics for each type and rated size of VFD.
      g. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following pending adherence to footprint and EtherNet/IP communication requirements:
   1. Allen-Bradley.

B. Footprint Requirements:
   1. The VFD enclosure shall fit within the limits of the allocated footprint indicated on the Drawings. Custom work must be performed if required for fitting the VFD enclosure within the allocated footprint.

C. EtherNet/IP:
   1. The VFD shall communicate with the Allen-Bradley PLC via EtherNet/IP without the use of any programming, configuration, software, or hardware.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Sinusoidal pulse width modulated (PWM) type drive.
      a. Six-pulse insulated gate bipolar transistor (IGBT) power section.
      b. Microprocessor based controls.
      c. Line and load reactors.
      d. Input and output isolation contactors.

B. Ratings:
   1. Voltage:
      a. Input voltage: 480 volts within 10 percent, 3-phase, 60 hertz.

C. Operational features:
   1. Protective features:
      a. Provide the following minimum protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
         8) Bolted Ground Fault
   2. Control mode:
      a. Operation in either a constant volts/hertz or sensorless vector mode:
         1) The control mode selectable using the programming keypad.
   3. Frequency control:
      a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
      b. Programmable minimum frequency.

c. Programmable maximum frequency.

4. Acceleration/deceleration:
   a. Separately adjustable acceleration and deceleration rates:
      1) Each rate adjustable from 0.01 to 3,600 seconds.
5. Spinning load:
   a. The VFD shall be capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
6. Programmable loss of signal:
   a. Upon loss of speed reference the VFD shall be programmable to either:
      1) Stop.
      2) Maintain current speed.
      3) Default to pre-selected speed.
7. Power interrupt ride-through:
   a. The VFD shall be capable of continuous operation in the event of a power loss of 5 cycles or less.
8. Inputs/Outputs:
   a. Manufacturer’s standard number the following:
      1) Analog inputs:
         a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
      2) Analog outputs:
         a) Programmable 4 to 20 milliamperes isolated.
      3) Discrete inputs:
         a) Programmable.
      4) Discrete outputs:
         a) Programmable.
         b) Form C relay contacts.
      5) Potentiometer 3-wire input.
   b. Provide additional inputs/outputs as required to meet the control functions indicated on the Drawings.
9. Communications:
   a. Provide each VFD with an EtherNet/IP communications interface module.
   b. Provide each VFD with an end-of-line termination resistor for the network specified above.
10. Automatic control:
    a. PID capability utilizing an internal or external setpoint:
       1) Selectable setpoint source.
11. Diagnostics:
    a. Store a minimum of 4 fault conditions in non-volatile memory on a first in-first out basis.
    b. Operational parameters stored at the time of a the fault:
       1) Operating frequency.
       2) Drive status.
       3) Power mode.
    c. Fault memory accessible via RS-232, RS-422 or RS-485.
12. Automatic restart:
    a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
       1) Programmable for up to 9 restart attempts.
       2) Adjustable time delay between restart attempts.

2.06 COMPONENTS

A. Enclosure:
   1. NEMA Type 12 or inside motor control center: as indicated on the Drawings.
   2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
      a. Provide cooling device failure alarm.

B. Power disconnect:
   1. Flange mounted motor circuit protector, fused switch, or thermal magnetic circuit breaker.
   2. Lockable in the OFF position.

C. Reactors:
   1. Line reactors: 3 percent input and 3 percent output.

D. Keypad:
   1. Provide each VFD with a keypad for programming and control.
   2. Keypad requirements:
      a. Password security to protect drive parameters.
      b. Mounted on the door of the VFD, on the door of the motor control center, or remote mounted as indicated on the Drawings.
      c. Back-lit LCD:
         1) Minimum of 2 lines with a minimum of 16 characters per line.
      d. Programming and display features language: English.
      e. Capable of displaying the following parameters:
         1) Speed (percent).
         2) Output current (amperes).
         3) Output frequency (hertz).
         4) Input voltage.
         5) Output voltage.
         6) Total 3-phase kilowatt.
         7) Kilowatt-hour meter.
         8) Elapsed run time meter.
         9) Revolutions per minute.
         10) Direct current bus voltage.
   3. In addition to all keys required for programming, provide the following controls on the keypad:
      a. Auto/manual selector.
      b. Start pushbutton.
      c. Stop pushbutton.
      d. Jog pushbutton.
      e. Speed increment.
      f. Speed decrement.
      g. Forward/reverse selector.
      h. Run LED indicator.
      i. Program LED indicator.
      j. Fault LED indicator.
   4. Provide the VFD with the hardwired controls as indicated on the Drawings.

E. Control power transformer:
   1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
   2. With primary and secondary fusing.
   3. Sized to power all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

F. VFD input contactor:
   1. Provide the VFD with a contactor between the incoming power and the VFD:
      a. Provide with all circuitry to control the contactor:
         1) On motor start, close the input contactor.
         2) After the motor is stopped, open the input contactor.

2.07 ACCESSORIES

A. VFD Cable where the cable between the VFD and the motor exceeds 100 feet:
   1. For conductors #10 through #4/0, provide Belden CSA VFD Cable
   2. For conductors 250 kcmil through 500 kcmil Belden Symmetrical Design VFD Cable

B. Metal oxide varistors:
   1. Provide protection for the VFD against:
      a. Line transients: 5,000 volt peak minimum.
      b. Line to ground transients: 7,000 peak minimum.

C. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure finish shall be manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL

A. VFDs, factory testing:
   1. General:
      a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
      b. All VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
      c. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
   2. Failure of any component during testing requires repair of the faulted component and complete retest.

3. Testing sequence:
    a. Submit a detailed test procedure for the VFD factory test:
        1) A minimum of 8 weeks in advance of the proposed testing date.
        2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.
4. Component tests:
    a. Preliminary inspection:
        1) Verify that all components are correct.
        2) Verify that all connections are properly torqued.
    b. Printed circuit boards:
        1) Test for correct component placement and value and complete board functional test to ensure proper performance with specified tolerances.
        2) Heat cycle test for 48 hours at 60 degrees Celsius.
        3) Apply control power to microprocessors, printed circuit boards, diagnostic boards, and similar devices including software to test for proper operation, sequencing, logic, and diagnostics.
        4) Test operation of all analog and discrete inputs and outputs.
    c. Wiring:
        1) Control and power wiring continuity verified point-to-point.
        2) Hi-pot power and control wiring at manufacturer's recommended levels.
        3) Verify ground bond resistance.
    d. Load testing:
        1) No load testing in accordance with the manufacturer's standard factory test procedure.
        2) Full load testing:
            a) Test each VFD and a representative motor with the system logic and a dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
            b) Load test each VFD at a minimum ambient temperature of 40 degrees Celsius.
                (1) Monitor and record temperature rise.
                (2) Once temperature rise stops continue to operate the VFD for a minimum of 2 hours.
                    (a) If operating temperature exceeds the rated value, repair or replace the VFD and retest.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete the installation of the VFD (free-standing or within motor control center).
   2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
   3. Perform work in accordance with manufacturer's instructions and shop drawings.
   4. Furnish components and equipment as required to complete the installation.
   5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
   6. Install free-standing enclosures on 3-1/2 inch raised concrete housekeeping pad:
      a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
      b. Weld and/or bolt the VFD frame to the leveling channels.
   7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
      a. Improperly cut holes will require that the entire panel be replaced:
         1) No hole closers or patches will be allowed.
   8. Bundle circuits together and terminate in each unit:
      a. Tie with nylon wire ties.
      b. Label all wires at each end with wire numbers shown on the approved control drawings.
      c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. Provide the services of a VFD manufacturer representative for startup assistance and training:
   1. Inspection and field adjustment:
      a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
   2. Startup field testing:
      a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
      b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

3.08 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameters and protective device settings:
   1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
   2. Provide documentation of VFD settings included but not limited to:
      a. Minimum speed.
      b. Maximum speed.
      c. Skip speeds.
      d. Current limit.
      e. Acceleration time.
      f. Deceleration time.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Demonstrate the operation of each VFD to the Engineer's and Owner's satisfaction.

C. Training:
   1. Provide instruction of the Owner’s operation and maintenance staff on the operation and maintenance of the VFD.
   2. Separate classes are required for the operations staff and maintenance staff:
      a. Operations staff training shall consist of two identical training sessions, each consisting of 1 session per day for two days, with each session lasting 4 hours for a total class time of 8 hours:
         1) The sessions shall be scheduled with the Owner to ensure all operators have the opportunity to attend.
      b. Maintenance staff training shall consist of 1 session per day for one day with each session lasting for 8 hours, for a total class time of 8 hours.
      c. Instruction shall occur at the Owner’s facility and shall utilize the actual VFDs installed at the site.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16272

DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Enclosed dry-type transformers:
      a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
      b. Primary voltage 600 volts and below.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 – Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI):
   1. C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type.
   2. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.
   2.

D. National Electrical Manufacturers Association (NEMA):
   1. TP-1 - 2002 - Guide for Determining Energy Efficiency for Distribution Transformers.
   2. TP-2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.

E. Underwriters Laboratory (UL):
   1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTIONS

A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
   1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 16050 after all derating factors have been applied.
   2. Suitable for continuous operation at full rating with normal life expectancy in accordance with ANSI C57.96.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Nameplate data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   4. Inrush current.
   5. Insulation system and temperature constraints.
   6. Number and rating of taps.
   7. Sound levels.
   8. Connection diagrams:
      a. Primary.
      b. Secondary.
   9. BIL rating.
   10. Required clearances.
   11. Percent impedance.
   12. Efficiency.
   13. Certification of full capacity capability at the Project elevation and ambient conditions.
   14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section16050:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. For equipment installed in structures designated as seismic design category A or B:
      a. Provide manufacturer’s installation instructions and anchoring details for connecting equipment to supports and structures.

3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
    1. General Electric
    2. Schneider Electric/Square D.
    3. EATON
    4. Or approved equal.

B. Drive isolation transformers: One of the following or equal:
    1. General Electric
    2. Schneider Electric/Square D.

3. EATON
4. Or approved equal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Cores:
   1. Non-aging, grain-oriented silicon steel.
   2. Magnetic flux densities below the saturation point.

B. Windings:
   1. High-grade magnet wire.
   2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
      a. Cured to reduce hot-spots and seal out moisture.
   3. Material electrical grade:
      a. Copper.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. 10 kilovolts BIL for 600-volt class windings.
   2. Sound levels, in accordance with ANSI 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

   3. Taps:
      a. 15 kilovolt-amperes and less:
         1) Two 5 percent full capacity primary taps below rated voltage.
      b. 25 kilovolt-amperes and larger:
         1) Four 2.5 percent full capacity primary taps below rated voltage.
         2) Two 2.5 percent full capacity primary taps above rated voltage.
      c. Operated by a tap changer handle or tap jumpers accessible through a panel.
   4. Terminals:
      a. UL listed for either copper or aluminum conductors.
      b. Rated for 75 degrees Celsius.
   5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with ANSI C57.96.

B. Transformers less than 15 kilovolt-amperes:
   1. Insulation class: 185 degrees Celsius.

2. Temperature rise: 115 degrees Celsius.

C. Energy efficient transformers 15 kilovolt-amperes and larger:
   1. Insulation class: 220 degrees Celsius.
   2. Temperature rise: 115 degrees Celsius, except as noted below:
      a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
   3. Efficiency:
      a. In accordance with NEMA TP-1.
      b. Measured in accordance with NEMA TP-2.

D. Enclosures:
   1. Heavy gauge steel:
      a. Outdoor: Moisture and water resistant with rodent screens over all openings and in a weather-protected enclosure, NEMA Type 3R.
      b. Indoor: NEMA Type 2.
   2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
   3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
      a. Neoprene vibration pads and sleeves.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Nameplates:
   1. Non-corrosive metal or UL listed non-metallic:
      a. Stamped, engraved or printed with the following information:
         1) Phases.
         2) Frequency.
         3) Kilovolt-ampere rating.
         4) Voltage ratings.
         5) Temperature rise.
         6) Impedance.
         7) Insulation class.
         8) BIL rating.
         9) Connection diagram.
         10) Weight.
         11) Manufacturer.
         12) The identification “transformer”.
         13) Classes of cooling.
         14) Tap voltage(s).
         15) Vector diagram.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer’s standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL

A. Factory tests:
   1. Applied voltage test to each winding and from each winding to the core:
      a. 600-volt class winding 4.5 kilovolt.
   2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
   3. Voltage ratio and polarity.
   4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
   5. Perform all tests in accordance with UL 1561.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Floor, wall, platform, motor control center, packaged power supply, or roof mounted, as indicated on the Drawings.
   2. Locate where not in direct contact with building structure.
   3. Install on double-deflection mounts selected for maximum isolation manufactured by Korfund or equal.
   4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
   5. Ground the enclosure:
      a. To an equipment ground conductor in the conduit.
      b. To the facility grounding electrode system.
   6. Floor mounted transformers:
      a. Install transformers on 3-1/2-inch housekeeping pads.
      b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer's recommendations.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16305

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Short circuit fault analysis study.
   2. Protective device coordination study.
   3. Arc-flash hazard study.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

A. As specified in Section 16050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).
   2. 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
   3. 315 - IEEE Standards Electrical and Electronics Graphic and Letter Symbols and Reference Designations.
   4. 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).
   5. 902 - IEEE Guide for Maintenance, Operation and Safety on Industrial and Commercial Power Systems (Yellow Book).
   6. 1015 - IEEE Recommended Practice For Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems - Corrigendum 1 (Blue Book).
   7. 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations.

C. National Fire Protection Association (NFPA):
   1. 70E - Standard for Electrical Safety in the Workplace.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. General study requirements:
   1. Scope:
      a. The short-circuit fault analysis, protective device coordination and arc-flash hazard studies shall include all equipment in the power distribution system including but not limited to:
         1) Utility equipment.
         2) Switchgear.
         3) Switchboards.
         4) Transformers:
            a) Including all dry-type transformers.
         5) Motor control centers.
         6) Free standing variable frequency drives and starters.
         7) Disconnect switches.
         8) Motors.
         9) Panelboards:
            a) Including all 240 and 208 volt systems.
         10) Vendor control panels.
         11) HVAC equipment.
      b. Study scenarios:
         1) The studies shall include all possible electrical system configurations, for example:
            a) Operation on normal (utility) source.
            b) Main-breakers closed, tie-breaker open.
            c) Either main-breaker open, tie-breaker closed.
   2. Obtain, for all equipment, the required data for preparation of the study, including, but not limited to:
      a. Transformer kilovolt-ampere (kVA) and impedances.
      b. Bus withstand ratings.
      c. Cable and bus data.
      d. Protective device taps, time dials, instantaneous pickups, and time delay settings.
   3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
      a. Utility tolerances and voltage variations.
   4. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.
   5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.
   6. Bus and conductor data:
      a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
      b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.

c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
d. Use bus withstand values for all equipment having buses.
e. Use medium voltage cable reactances based on typical dimensions of shielded cables with 133 percent insulation levels, unless otherwise indicated.

7. Motors:
   a. Each motor shall be individually modeled:
      1) Grouping of motors for fault contribution current is not acceptable.
   b. Motors with variable frequency drives may be assumed to have no contribution to fault current.
8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
   a. Initial short-circuit fault analysis:
      1) Based on the Contract Documents and Electric Utility information.
      2) The initial short-circuit fault analysis report shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
      3) Provide a list of assumptions used in the initial study.
   b. Final short-circuit analysis:
      1) The final short-circuit fault analysis shall modify the initial analysis as follows:
         a) Utilize the actual equipment provided on the project.
         b) Utilize conductor lengths based on installation.
2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 and 4 cycle, interrupting symmetrical RMS, and 30 cycle steady state short-circuit current values at each piece of equipment in the distribution system.
3. Evaluate bus bracing, short circuit ratings, fuse interrupting capacity and circuit breaker adjusted interrupting capacities against the fault currents, and calculate X/R values:
   a. Identify and document all devices and equipment as either inadequate or acceptable.
4. Calculate line-to-ground and double line-to-ground momentary short circuit values at all buses having ground fault devices.
5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including Utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:
1. Furnish protective device settings for all functions indicated on the Drawings, including, but not limited to:
   a. Current.
   b. Voltage:
      1) Provide settings for all voltage relays based upon actual Utility and tolerances and specifications.
   c. Frequency:

1) Provide settings for all frequency relays based upon actual Utility tolerances and specifications.

d. Negative sequence.

e. Reverse power.

f. Machine protection functions:

1) Provide settings for all motor protective relays based on the manufacturer's recommended protection requirements.

2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:

a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:

1) Typical time-current curves for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.

b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:

1) These details can be included on the TCC.

c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:

1) These details can be included in the TCC.

3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include Utility relay and fuse characteristics, medium voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor characteristics, and characteristics of other system load protective devices:

a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards and fused disconnect switches.

b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.

c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.

d. On the TCCs show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters and transformer damage curves.

e. Cable damage curves.

f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.

g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream device to avoid nuisance tripping.

4. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:

1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:

a. Perform study with 15 percent arcing fault variation as defined by IEEE 1584.

b. Perform arc-flash calculations at minimum and maximum utility fault contributions.

c. Perform arc-flash calculations for both the line side and load side of switchgear, switchboard, motor control center and panelboard main breakers.
d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
e. Protective device clearing time shall be limited to 2 seconds, maximum.

2. Provide executive summary of the study results.
   a. Provide summary based upon worst case results.
3. Provide a detailed written discussion and explanation of the tabulated outputs.
   a. Include all scenarios.
4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
   a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
   b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

E. By virtue of the fact that this is a professional study the Owner reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash study shall be modified based on the results of the meetings with the Owner.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Initial studies and reports:
1. Include the following in the initial short-circuit current report:
   a. List of all devices included in the studies.
   b. A description of all operating scenarios.
   c. Form and format of arc flash labels.

C. Final studies and reports:
1. Format and quantity:
   a. Provide 6 bound copies of all final reports.
   b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
   c. Provide the number of copies specified in Section 01330**.**
   Provide all related data files including any SKM files.
2. Include the sections below in the final report:
   a. Copies of correspondence and data obtained from the Electric Utility Company.
   b. Letter certifying the inspection and verification of existing equipment.
   c. One-line diagrams:
      1) The following information shall be included at a minimum:
         a) Motor horsepower.
         b) Transformer data:
            (1) kVA.
            (2) Configuration.
         c) Cable data:

(1) Insulation.
(2) Size.
(3) Length.

2) One-line diagrams shall be fully legible at 11-inch by 17-inch size.

d. Include in the short-circuit fault analysis study:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) Normal system connections and those, which result in maximum fault conditions.
   3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
   4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.

e. Protective device coordination study shall include:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) List all requirements used in the selection and setting criteria for any protective devices.
   3) Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.
   4) TCCs graphically indicating the coordination proposed for the system on log-log graphs. Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
   5) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.

f. Include in the arc-flash study:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) Normal system connections and those, which result in maximum arc-flash conditions.
   3) Arc-flash raw data, calculations, and assumptions.
   4) Arc-flash label data:
      a) Identifying the content of each label.
      b) Identifying the location of each label.

D. Certification:
   1. Submit written certification, sealed, and signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct.

E. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

F. The Engineer will review all studies and reports. After review, the Engineer will make recommendations and/or require changes to be made to the short-circuit analysis, protective device coordination or arc-flash studies. These changes shall be provided as part of the scope of work.

G. Submit course outline for Owner's training.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Qualifications of the entity responsible for electrical system studies:
   1. The studies shall be performed, stamped, and signed by a professional engineer registered in the state where the project is located.
   2. A minimum of 5 years experience in power system analysis is required for the individual in responsible charge of the studies.
   3. The short-circuit analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
      a. Point-to-point calculations are not acceptable.

C. The study shall be performed by an independent firm or the equipment manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. Submit the initial short-circuit analysis study before submittal of any electrical equipment.

B. Initial electrical system study meeting.

C. Submit the preliminary short-circuit analysis protective device coordination and arc flash studies.

D. Second electrical system study meeting for preliminary results.

E. Final arc-flash meeting and final short-circuit analysis, protective device coordination, and arc-flash studies.

F. Label equipment with approved arc flash labels.

G. Owner’s training.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START UP (NOT USED)

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Electrical system study software one of the following or equal:
   1. ETAP by Operation Technology Inc.
   2. Powertools by SKM Systems Analysis.
   3. Paladin DesignBase by Power Analytics Corporation.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Arc-flash hazard labels:
   1. Dimensions:
      a. Minimum 5 inches by 3.5 inches.
   2. Materials:
      a. Polyester with polyvinyl polymer over-laminate.
      b. Self-adhesive.
      c. Resistant to:
         1) UV.
         2) Chemicals and common cleaning solvent resistant.
         3) Scuffing.
         4) Wide temperature changes.
   3. Contents:
      a. Short-circuit bus identification.
      b. Calculated incident energy (calories/square centimeter) range.
         1) Based on worst case study results.
      c. Hazard/risk, personnel protective equipment category number.
      d. Arc-flash protection boundary.
      e. Shock hazard boundary:
         1) The CONTACTOR may provide separate labels for indication of the shock hazard boundary.
      f. Description of the combined level of personnel protective equipment.
   4. Color scheme:
      a. For locations above 40 calories/square centimeter:
         1) White label with red “DANGER” strip across the top.
         2) Black lettering.
      b. For locations below 40 calories/square centimeter:
         1) White label with orange “WARNING” strip across the top.
         2) Black lettering.
   5. Label Warrant:
      a. Minimum 5 year on all label material.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. After review and acceptance of the arc-flash hazard study by the Engineer, install all arc-flash hazard labels:
   1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
   2. At a minimum install labels in the following locations:
      a. The front of each main or incoming service compartment.
      b. The front of each low voltage switchgear section.
      c. The front of each medium voltage circuit breaker door.
      d. The front of each accessible auxiliary or conductor compartment.
      e. Each accessible rear or side vertical section.
      f. Each motor control center compartment.
      g. Each panelboard covered by the study.
      h. Each control panel, individual starter or VFD or other equipment covered by the scope of the study.
   3. Install labels prior to equipment energization.

C. After review and acceptance of the arc-flash hazard study and coordination study by the Engineer, adjust protective device settings per final study prior to equipment energization.
   1. Devices which require power for configuration may be set during energization, but before any subfed loads are energized.
   2. Ensure that settings for upstream equipment are set prior to energizing downstream devices.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
   1. Remove and replace any improperly applied labels.

2. Repair the equipment finish damaged by removal of any label.
3. Install labels to within 1/64 inch of level or plumb across the entire dimension of the label.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Training:
   1. Provide a minimum of 1 training sessions for the Owner's electrical maintenance personnel:
      a. Each session shall be a minimum of 4 hours.
   2. The training shall cover at a minimum:
      a. Hazards associated with arc-flash.
      b. Causes of arc-flash.
      c. Explanation of the arc-flash labels installed on the Owner's electrical equipment.
      d. Proper use of personal protective equipment.
      e. PPE requirements for maintenance work.
   3. The individual in charge of the arc-flash study or qualified representative shall conduct the training sessions.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16411

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fusible and non-fusible disconnect switches.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16075 - Electrical Identification.
      d. Section 16305 - Electrical System Studies.
      e. Section 16494 - Low Voltage Fuses.

1.02 REFERENCES

A. As specified in Section 16050.

B. Underwriters Laboratories Inc. (UL):
   1. 20 - General-Use Snap Switches.
   2. 98 - Enclosed and Dead-Front Switches.
   3. 508 - Standard for Industrial Control Equipment.

C. National Electric Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment.
   2. KS 1-2001- Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
   1. Safety switches and disconnect switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.

B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer.
   2. Manufacturer's specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.
      c. Horsepower.
      d. Short circuit rating.
   4. Fused or non fused.
   5. NEMA enclosure type.
   6. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   7. Weight.
   8. Cross-referenced to the disconnect schedule indicated on the Drawings.

C. Shop drawings:
   1. Manufacturer's installation instructions:
      a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
      b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
   2. Identify motor or equipment served by each switch; indicate nameplate inscription.

D. Installation instructions:
   1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 and calculations:
      a. Stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Regulatory requirements:
   1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).

2. UL 98 - Enclosed and Dead-Front Switches.

C. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 and submit results for Engineer's review.

B. After successful review of the initial fault current study, as specified in Section 16305, submit complete equipment submittal as specified in the Submittal article of this Section for Engineer's review.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
1. Schneider Electric/Square D Company.
2. Eaton/Cutler-Hammer.
3. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Switch mechanism:
   1. Quick-make, quick-break heavy-duty operating mechanisms:
      a. Provisions for padlocking the switch in the Off position.
      b. A minimum of 90-degree handle travel position between Off and On positions:
         1) Provide handle position indicators to identify the handle position.
      c. Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
         1) With an externally operated override.

B. Switch interior:
   1. Switch blades visible when the switch is Off and the cover is open.
   2. Lugs:
      a. Front accessible.
      b. Removable.
      c. UL listed for 60/75-degree Celsius copper conductors.
   3. Current carrying parts completely plated to resist corrosion.
   4. Removable arc suppressors to facilitate easy access to line side lugs.
   5. Furnish equipment ground kits for every switch.

C. Fused switches:
   1. Furnish with fuses as indicated on the Drawings:
      a. Provide fuses as specified in Section 16494.
   2. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
      a. Ratings 100 amperes through 600 amperes at 240 volts.
      b. Ratings 30 amperes through 600 amperes at 600 volts.
      c. Provide spring reinforced and plated fuse clips.

D. Ratings:
   1. UL horsepower rated for AC or DC with the rating not less than the load served.
   2. Current:
      a. 30 to 1,200 amperes.
   3. Voltage:
      a. 250 volts AC, DC.
      b. 600 volts (30 A to 200 A, 600 volts DC).
   4. Poles:
      a. 2, 3, 4, and 6 poles.
   5. UL listed short circuit ratings:
      a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
      b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).

c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).

6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 for the installed location.

E. Size, fusing and number poles as indicated on the Drawings or as required:
1. Provide solid neutral where indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.

C. NEMA Type 7 and 9 enclosures furnished with drain and breather kit when used in outdoor applications.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
2. Provide all mounting brackets, stands, supports and hardware as required:
a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate

aboveground or above decks, where there is no structural wall or surface for box.

3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
    a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
    b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
4. Provide a nameplate for each disconnect switch:
    a. Provide per requirements specified in Section 16075.
    b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage molded case circuit breakers as indicated on the Drawings and as specified.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16305 - Electrical System Studies.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. AB 3. - Molded Case Circuit Breakers and Their Application.

C. Underwriter's Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Catalog cut sheets.
   2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. Allen-Bradley.
   2. Eaton/Cutler-Hammer.
   3. Schneider Electric/Square D.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Conforming to UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the "OFF" position.
   3. Arc extinction:
      a. In arc chutes.
   4. Voltage and current ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Minimum frame size 100A.
   5. Interrupting ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Modify as required to meet requirements of the short circuit fault analysis - as specified in Section 16305.
      c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.)

B. Motor circuit protectors:
   1. Instantaneous only circuit breaker as part of a listed combination motor controller.
   2. Each pole continuously adjustable in a linear scale with ‘LO’ and ‘HI’ settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Terminals:
   1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.

B. Case:
   1. Molded polyester glass reinforced.
   2. Ratings clearly marked.

C. Trip units:
   1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
   2. Thermal magnetic:
      a. Instantaneous short circuit protection.
      b. Inverse time delay overload.
      c. Ambient or enclosure compensated by means of a bimetallic element.

3. Solid state:
    a. With the following settings as indicated on the Drawings.
        1) Adjustable long time current setting.
        2) Adjustable long time delay.
        3) Adjustable short time pickup.
        4) Adjustable short time delay.
        5) Adjustable instantaneous pickup.
        6) Adjustable ground fault pickup as indicated on the Drawings.
        7) Adjustable ground fault delay as indicated on the Drawings.

D. Provide ground fault trip devices as indicated on the Drawings.

E. Molded case circuit breakers for use in panelboards:
    1. Bolt-on type.
        a. Plug-in type breakers are not acceptable.
    2. Ground fault trip devices as indicated on the Drawings.

2.07 ACCESSORIES

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
    1. UL 489.
    2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16426

SOLID STATE SOFT STARTER (SSS)

PART 1 - GENERAL

1.01 SUMMARY

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals required to furnish and install solid state starters (SSS), complete and operational with controls and accessories as shown on the Drawings and as specified.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 01330 - Submittal Procedures.
   2. Section 16050 - Common Work Results for Electrical.
   3. Section 16075 - Electrical Identification.
   4. Section 16950 - Field Electrical Acceptance Tests.

C. Coordination: CONTRACTOR shall coordinate starting and operating requirements between the pump and SSS manufacturers. CONTRACTOR shall submit an acceptance letter from the driven equipment and motor manufacturers stating that each SSS will fully meet all starting and operating requirements of the respective driven equipment/motor combination. CONTRACTOR shall be responsible for coordinating all SSS units with the driven equipment to obtain successful operation throughout the driven equipment speed range.

1.02 QUALITY ASSURANCE

A. References:
   1. This section references the latest revisions of the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ANSI/NEMA ICS 2	Industrial Control Devices, Controllers and Assemblies
UL 845	Motor Control Centers
UBC	Uniform Building Code
NEC	National Electric Code

1.03 UNDERWRITERS LABORATORIES INC.

A. The complete motor control center shall be listed and labeled for the purpose for which it is used by the Underwriters Laboratories Inc. (UL).

1.04 SUBMITTALS TO BE PROVIDED

A. Control Schematics for all equipment.
B. Dimensions and weight.
C. Installation instructions and seismic mounting details.
D. Elementary, connection and interconnection diagrams.
E. Time-current curves for all protection devices.
F. List of starters and feeder tap compartments indicating the size and type of circuit protection.
G. Front View
H. Plan View
I. Operating and maintenance material.
J. Name of dealer's repair facility and parts stocking agreement with the factory.
K. A toll-free or local phone number with 24/7 emergency monitoring/call back is required.

1.05 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the motor starters and circuit protective devices within the assembly.

B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.07 FIELD MEASUREMENTS

A. Installing Contractor to verify equipment proposed shall fit into the available space. Coordinate installation with other trades and notify the approval authorities of any interferences or conflicts in the MCC system power and control wing.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Allen Bradley
B. Square D
C. Or Approved Equal

2.02 SOLID-STATE SOFT STARTER

A. Solid State Soft Starter

1. The solid-state reduced voltage starter shall be UL and CSA listed.
2. The solid state reduced voltage starter shall be an integrated unit with power SCR's, heat sink, logic board, paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing.
3. The SCR based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 1600 volts PIV. The starter shall be three-phase, 60 Hz, and rated for the horsepower, current, and voltage as shown on the drawings.
4. Units shall include an integrated fan controlled by thermal sensors on the heat sink. Fan shall automatically operate during the start ramp and if internal temperature on the heat sink exceeds 60 degree C.
5. Units using triacs or SCR/diode combinations shall not be acceptable.
6. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt effects.
7. The logic board shall be identical for all ampere ratings and voltage classes and shall be conformal coated to protect environmental concerns.
8. The paralleling run bypass contactor shall energize when the motor reaches 90% of full speed and close/open under 1 times motor current.
9. The paralleling run bypass contactor shall utilize an intelligent coil controller to limit contact bounce and optimize coil voltage during varying system conditions.
10. Starter shall be provided with electronic overload protection as standard and shall be based on an inverse time-current algorithm. Overload protection shall be capable of being disable during ramp start for long acceleration loads via a DIP switch setting on the device keypad.
11. Overload protection shall be adjusted via the device keypad and shall have a motor full load amp adjustment from 30 to 100% (3.2:1) of the max continuous ampere rating of the starter.
12. Starter shall have selectable overload class setting of 5, 10, 20 or 30 via a DIP switch setting on the device keypad.
13. Starter shall be capable of either an electronic or mechanical reset after a fault.
14. Units using bi-metal overload relays are not acceptable.
15. Over temperature protection (on heat sink) shall be standard.
16. Starters shall provide protection against improper line side phase rotations as standard. Starter will shut down if a line side phase rotation other than A-B-C exists. This feature can be disabled via a DIP switch on the device keypad.
17. Starters shall provide protection against a phase loss as standard. Starter will shut down if a 50% current differential between any two phases is encountered. This feature can be disabled via a DIP switch on the device keypad.
18. Start shall provide protection against a motor stall condition during the start ramp as standard. This feature can be disabled via a DIP switch on the device keypad.
19. Starter shall provide protection against a motor jam condition during run as standard. This feature can be disabled via a DIP switch on the device keypad.

20. Starter shall be provided with a form C normally open (NO), normally closed (NC) contact that shall change state when a fault conditions exists. Contacts shall be rated 240V AC and 24V DC max, 3 amps as standard. In addition, an LED display on the device keypad shall indicate type of fault (Overtemp, Phase Loss, Jam, Stall, Phase Reversal, and Overload).
21. The following control function adjustments on the device keypad are required:
    a) Selectable Torque Ramp Start or Current Limit Start
    b) Adjustable Kick Start Time, 0-2 seconds
    c) Adjustable Kick Start Torque, 0-85%
    d) Adjustable Ramp Start Time; 0.5-180 second
    e) Adjustable Initial Starting Ramp Torque; 0-85%
    f) Adjustable Smooth Stop Ramp Time; 0-60 seconds.
22. Enclosed units shall include a thermal magnetic circuit breaker or HMCP for short circuit protection and quick disconnect means.
23. Starters and breakers/HMCPs shall be rated per UL508D for a withstand rating of 65 kAIC rms.
24. Units enclosed in motor control centers shall be of the same manufacturer as that of the circuit breaker and motor control center for coordination and design issues.
25. The manufacturer of the solid-state starter shall employ a field based factory service organization for the purpose of start up and repair of units.
26. Maximum continuous operation shall be at 100% of continuous amp rating.
27. Separate control terminals shall be provided for 120V AC circuitry as indicated on the Drawings and as required for proper functioning of the device.
28. Separate control terminals shall be provided for 24V DC power, logic level signals for permissive, start, jog forward, ramp start overload override and electric reset.
29. Control terminals shall be pull-apart for easy access and wiring.
30. Optional external interface circuitry shall include 120-volt relay logic interface capability.
31. A removable Customer Interface Module (CIM) shall be provided that allows for full adjustment of control and protection functions thru the use of potentiometers and DIP switches.
32. Power terminations shall consist of pressure type terminals.
33. Enclosure

    a. The following shall be included:

        1. The operating handle of the disconnect, when supplied, shall always remain connected to the breaker or switch. The operating handle shall not be mounted on the door of the enclosure, but on the controller for safe “stand-aside” operation. The position of the operating handle will indicate ON or OFF position of switch or circuit breaker and include provision for padlocking in the OFF position.

        2. Interlock provisions shall prevent unauthorized opening or closing of the starter door with the disconnect in the ON position.

3. The structure, when floor-mounted, shall be provided with adequate lifting means and shall be capable of being rolled or lifted into installation position and bolted to the floor.

34. The manufacturer of the solid-state starter shall employee a field based factory service organization for the purpose of start up and repair of units. (Third party service contractors are not acceptable.)
35. Maximum continuous operation shall be at 100% of continuous amp rating.

B. Additional (True) Bypass Contactor
   1. This Bypass starter is in addition to the “paralleling run bypass contactor” indicated above.
   2. The Bypass Contactor shall be:

      a. Fully rated for the future motor sizes as indicated on the Drawings.

      b. NEMA rated and UL listed

C. Controls
   1. Furnish and install the following for controls.

      a. 300VA control transformer (minimum)

      b. Start push button

      c. Stop push button

      d. Hand-Off-Auto selector switch (In Auto, the pump starts and stops based on two signals from two existing level probes.)

      e. Running pilot light

      f. Ability to take a contact from a device to a timer and from timer to a form C contact relay.

      g. A duplicate of the above.

      h. A 120V, 10 amp rated contact shall be energized when the pump is running to start and stop the chlorine feed pump.

      i. Contacts for future SCADA (running, alarm, and start/stop)

      j. Fully rated for the future motor sizes as indicated on the Drawings.

      k. NEMA rated and

      l. UL listed

   2. Submit the control schematic diagrams for approval by the Owner and Engineer prior to manufacturing:

PART 3 - EXECUTION

3.1 START-UP AND TEST

A. Make adjustments required to place system in proper operating condition.

B. A manufacturer's representative shall check and approve the installation before operation. He shall test operate the system in the presence of the ENGINEER and verify that the units conform to requirements. He shall revisit the jobsite as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

3.2 MANUFACTURER'S SERVICES

A. A factory-trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 2 visits, minimum 4 hours on-site for each visit, to the site. The first visit shall be for checking the completed installation and start-up of the system. The second visit shall be for instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the variable frequency drives conform to requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

END OF SECTION

SECTION 16445

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Panelboards serving facility feeder circuits, branch circuits or other utilization equipment at the voltage levels and configurations indicated on the Drawings.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16075 - Electrical Identification.
      d. Section 16285 - Surge Protective Devices.
      e. Section 16412 - Low Voltage Molded Case Circuit Breakers.

1.02 REFERENCES

A. As specified in Section 16050.

B. Underwriter's Laboratories, Inc. (UL):
   1. 67 - Standard for Panelboards.

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
   1. Service voltage and configuration as indicated on the panel schedules.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Manufacturer of panelboard.

2. Bill of material.
3. Assembly ratings including:
    a. Voltage.
    b. Phase.
    c. Continuous current.
    d. Short circuit interrupting rating.
4. NEMA enclosure type.
5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
6. Furnish circuit breaker submittals as specified in Section 16412.
7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.

C. Shop drawings:
1. Drawings to contain:
    a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
        1) Height.
        2) Length.
        3) Width.
    b. Weight.
    c. Anchoring locations.
    d. Breaker layout drawing with dimensions:
        1) Location of the main, branches, solid neutral, and ground.
    e. Conduit entry/exit locations.
        1) Identify all conduit entry/exit locations and restrictions.
    f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operations and maintenance manual:
1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
    a. Including but not limited to:

1) Instruction narratives and bulletins.
2) Renewal parts lists.
3) Time-current curves for all devices.

F. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Panelboards shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
1. Schneider Electric/Square D.
2. Or approved equal.

B. Circuit breakers:
1. Same manufacturer as the panelboard.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Provide panelboards with:
   1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
   2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

B. Short circuit rating:
   1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
   2. Testing method in accordance with UL 67.
   3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
   4. Panelboards shall be fully rated.

2.06 COMPONENTS

A. Enclosure:
   1. NEMA enclosure type as indicated on the Drawings.
      a. Where not indicated on the Drawings, as specified in Section 16050 for the installed location.
   2. Minimum width: 20 inches.
   3. Gutter space in accordance with the NEC:
      a. Minimum of 4 inches of gutter space.
   4. Dead-front, no live parts when the panelboard is in service.
   5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
   6. 4-piece front to provide ease of wiring access.
   7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
      a. Minimum 2 keys per panelboard.
      b. Key all panelboard locks alike.
   8. Circuit directory frame and card on the inside of the door.
   9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
   10. Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard.

B. Bus:
   1. General:
      a. Tin-plated copper
   2. Phase bus:
      a. Full size and height without reduction.
      b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:
         1) Limit current density to less than 1,000 amps per square inch.

c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.

3. Ground bus:
   a. Copper, solidly bonded.
4. Neutral bus:
   a. Provide where indicated on the Drawings.
   b. 100 percent rated.
   c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:
1. UL listed for copper and aluminum wire:
   a. Provide lugs rated for 75-degree Celsius terminations.
   b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As specified in Section 16412 and as indicated on the Drawings:
1. Provide all circuit breakers with bolt-on connections:
   a. Plug-in circuit breakers are not allowed.

2.07 ACCESSORIES

A. Surge protective devices:
1. Furnish panelboards with surge protective devices as indicated on the Drawings.
2. As specified in Section 16285.

B. Nameplates:
1. As specified in Section 16075.
2. Install on outside of door.
3. Indicating:
   a. Panel designation.
   b. Voltage.
   c. Number of phases and configuration.

C. Circuit identification labels:
1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
2. Type all information on the cards using designations in the panel schedules.
3. Laminated on both sides.

D. Pad locking mechanism:
1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
2. At a minimum, provide 1 mechanism per panelboard:
   a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.

B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL

A. Perform standard factory tests on the panelboards:
   1. Test in accordance with the latest version of NEMA and UL standards.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:
   1. Surface, flush or MCC mounted as indicated on the Drawings.
   2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
   3. Perform work in accordance with the manufacturer's instructions and shop drawings.
   4. Provide all brackets, hangers, supports, and hardware for mounting as required.
   5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
      a. Use only stainless steel mounting hardware.
   6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.

B. Provide typewritten schedule in each panelboard.

END OF SECTION

SECTION 16500

LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Luminaires, lamps, ballasts, poles, and accessories.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16422 - Motor Starters.

1.02 REFERENCES

A. As specified in Section 16050.

B. National Electrical Manufacturers Association (NEMA):
   1. C82.11 - High Frequency Fluorescent Lamp Ballast.

C. Underwriters Laboratories (UL):
   1. 1029 - High -Intensity Discharge Lamp Ballast.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions and abbreviations:
   1. BF: Ballast factor - Measure of light output from lamp operated by commercial ballast as compared to a laboratory standard reference ballast.
   2. BEF: Ballast efficacy factor - Value used to evaluate various lighting systems based on light output and power input.
   3. CCT: Correlated color temperature - Scientific scale to describe how "warm" or how "cool" the light source is, measured in Kelvin.
   4. Crest factor - ratio of peak lamp current to RMS or average lamp operating current.
   5. Efficacy - Lumen output per unit of power supplied to ballast (lumens per watt).
   6. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.

7. FC: Foot Candles - Measure of light level on a surface being illuminated.
8. HID: High intensity discharge - A lamp containing a filled arc tube in which the active element becomes vaporized and is discharged into the arc stream to produce light.
9. Instant start - Lamp starting method in which lamps are started by high voltage input with no preheating of lamp filaments.
10. Luminaire - Lighting unit.
11. Programmed start - lamp starting method that utilizes an integrated circuit to preheat the lamp filament while not allowing the lamp to ignite and then applies the open circuit voltage to start the lamp.
12. Pulse start - An HID ballast with a high voltage igniter that provides high voltage pulses to ionize the gas within the lamp.
13. Rapid start - Lamp starting method in which lamp filaments are heated while open circuit voltage is applied to facilitate lamp ignition.
14. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a ballast or other device.

1.04 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Product data:
   1. Luminaires:
      a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
      b. Provide for each luminaire type:
         1) Materials.
         2) Type of diffuser.
         3) Hardware.
         4) Gasketing.
         5) Reflector.
         6) Chassis.
         7) Finish and color.
         8) Ballast type and protection.
         9) Lamp:
            a) Type.
            b) Wattage.
            c) Lumen output:
               (1) Initial.
               (2) Mean.
            d) Correlated color temperature.
            e) Lamp lumen depreciation.
            f) Efficacy.
            g) Base.

10) Picture of luminaire.
11) Dimensioned drawings:
    a) Effective projected area rating for pole mounted luminaires.
12) Weight.
13) Photometric data:
    a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
    b) Luminaire dirt depreciation factor.
    c) Candlepower distribution curves.
    d) Average luminaire brightness.
    e) Lumen output charts.
14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
    a) Support methods shall be based on seismic requirements at the project site as specified in Section 16050.

c. Luminaire substitutions:
1) Provide complete literature for each luminaire substitution:
2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
    a) Photometric data:
        (1) IES file in standard IES format.
        (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
        (3) Candlepower distribution curves.
        (4) Average luminaire brightness.
        (5) Lumen output charts.
        (6) Power requirements in watts and volt-amperes.
    b) Calculations:
        (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
            (a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.
3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
4) Substitutions shall comply with all applicable building codes.

2. Ballast:
a. Provide for each ballast type:
1) Type of ballast.
2) Lamp wattage.
3) Input voltage.
4) Input watts.
5) Starting line current.
6) Operating line current.
7) Sound rating.
8) Power factor.
9) Ballast factor.
10) Starting temperature.

3. Photocell:
    a. Provide for each photocell type:
        1) Switching capacity.
        2) The means of adjusting the lighting pickup level.
        3) Enclosure type.
        4) Mounting method.
4. Luminaire poles:
    a. Submit complete data for each pole type including but not limited to:
        1) Material.
        2) Finish and color.
        3) Handholes.
        4) Anchoring.
        5) Luminaire attachment methods and fittings.
        6) Pole height.
        7) Pole dimensions.
        8) Bolthole circle layout and hardware.
        9) Accessories.
        10) Provide the EPA wind load rating.

C. Shop drawings:

D. Calculations:
1. Provide complete design calculations and installation documents for pole mounting piers and poles mounted from structures:
    a. Include in the calculations the wind and seismic requirements at the project site.
    b. Calculations and design shall be performed by and signed by a Professional Engineer registered in the state where the project is being constructed:
        1) Because this design is being provided by a Professional Engineer, the submittal will be reviewed for form and content but not reviewed for technical completeness, methods, or calculations.

E. Record documents:
1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.

B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Replace all lamps used during construction.

B. Furnish 5 percent of the quantity provided, but not less than 3 ballasts for every ballast type and size used.

C. Furnish 10 percent of the quantity provided, but not less than 12 new lamps for every lamp type and size used.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires: One of the following or equal:
   1. As noted on the Luminaire Schedule.

B. Lamps: One of the following or equal:
   1. General Electric Company.
   2. Osram Sylvania.
   3. North American Philips Lighting Company.

C.

D. Ballasts for fluorescent lamps: One of the following or equal:
   1. Advance.
   2. Universal.
   3. Osram Sylvania.
   4. General Electric Company.

E. Ballasts, HID lamps: One of the following or equal:

1. Advance.
2. Holophane.
3. Osram Sylvania.
4. General Electric Company.

F. Photo-electric cells: One of the following or equal:
   1. Intermatic.
   2. Tork.
   3. Paragon Electrical Products.

G. Substitutions:
   1. The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Luminaires:
   1. General:
      a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
      b. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
         1) The Specifications noted herein are an addition or supplement to the Luminaire Schedule.
   2. Exterior/outdoor luminaires:
      a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
         1) Wind levels at the project site without damage.
         2) Seismic levels at the project site.
      b. Corrosion-resistant hardware and hinged doors or lens retainer.
      c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.

B. Lamps:
   1. General:
      a. Provide lamps as indicated on the Luminaire Schedule.
      b. Lamps selected to mate with luminaires selected.
      c. Suitable for operation in any burning position unless otherwise indicated in the Contract Documents.
   2. Fluorescent lamps:
      a. Type T8 unless otherwise indicated on the Luminaire Schedule.
   3. Compact fluorescent lamps:
      a. 4-pin biax lamps unless otherwise indicated on the Luminaire Schedule.
   4. Incandescent lamps:

a. Frosted interior envelope, unless a specified lighting control system requires clear globe lamps.
b. Rated 130 Volts AC.
c. Lamp shape standard A or PS unless otherwise noted.
d. Lamps to utilize filaments recognized by dimming system manufacturer to reduce “ringing” and “chatter” of the lamp.

5. High intensity discharge lamps:
a. Metal halide lamps:
1) Pulse start.
b. High pressure sodium lamps:
1) Color corrected.

C. Photo-electric cells:
1. Photoelectric cells for control of multiple luminaires:
a. Self-contained.
b. Weatherproof.
c. Provided with time-delay features.
d. Sized to meet switching capacity of the circuit:
1) Based on ballast VA as indicated on the Drawings.
2. Photoelectric cell for control of a single luminaire:
a. Integral to the luminaire.

D. Luminaire control:
1. Lighting control relays or contactors as specified in Section 16422.

E. Ballasts:
1. General:
a. Energy saving type suitable for use with energy saving lamps where available.
b. Suitable for operation over the entire temperature range specified in Section 16050 for all luminaires not located in office areas or air conditioned spaces.
c. Meet FCC standard, Class A for EMI/RFI (FCC 47FCR Part 18 Non-consumer equipment).
d. Comply with applicable IEEE standards/guidelines for harmonic distortion and line voltage transient protection.
2. Ballasts for fluorescent lamps:
a. Operate as a parallel circuit allowing remaining lamp(s) to maintain full light output if one or more lamps fail.
b. Bear CBM and ETL labels.
c. High frequency electronic type:
1) Operate lamps above 20 kHz to avoid interference with infrared devices and to eliminate visible flicker.
d. High output application:
1) Utilize instant-start ballast.
e. Dimming application:
1) Utilize rapid-start ballast.
f. Motion sensor controlled or frequent starting application:
1) Utilize programmed-start ballast.
g. Total harmonic distortion of the input current less than 20 percent.
h. Sound rating: Class A or quieter.

i. UL Class P, Type 1 thermally protected, or individually fused in accordance with manufacturer's recommendations.
j. Auto restart circuitry to restart lamps without resetting power.
k. Input power source:
    1) As indicated on the Drawings.
    2) Use universal voltage ballasts when available.
    3) With sustained variations of within 10 percent (voltage and frequency) with no change to the ballast.
l. Power factor:
    1) Greater than 0.98 for primary lamp.
    2) Greater than 0.90 throughout the dimming range if applicable.
m. Ballast factor:
    1) Low energy: 0.70 minimum.
    2) Instant start: 0.90 minimum.
    3) High output: 1.20 minimum.
n. Lamp current crest factor:
    1) 1.7 or less for lamps operating in accordance with NEMA C82.11 parameters.
o. Minimum starting temperature:
    1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or specified in Section 16050:
        a) For standard T8 lamps: -29 degrees Celsius (-20 degrees Fahrenheit).
        b) For T8/HO: 10 degrees Celsius (50 degrees Fahrenheit).
        c) For Slimline T8 lamps: 0 degrees Celsius (32 degrees Fahrenheit).
        d) For energy saving T8: 16 degrees Celsius (60 degrees Fahrenheit).
p. Tolerate sustained open circuit and short circuit output conditions without damage.
q. High efficiency and meet all US state and federal efficacy laws.
r. Use dimming ballasts with dimmer controlled fluorescent fixtures where indicated on the Drawings.
s. Rated for location of installation.

3. Ballast for compact fluorescent lamps:
    a. Type:
        1) Programmed start.
        2) Incorporate lamp shutdown circuitry for end of lamp life protection.
    b. High frequency electronic type:
        1) Operate lamps above 20 kHz to avoid interference with infrared devices and to eliminate visible flicker.
    c. Input power source:
        1) As indicated on the Drawings.
        2) With sustained variations of within 10 percent (voltage and frequency) with no damage to the ballast.
    d. Lamp current crest factor:
        1) 1.7 or less for lamps operating in accordance with NEMA C82.1 parameters.
    e. UL Class P, Type 1 thermally protected, or be individually fused in accordance with manufacturer's recommendations.
    f. Power factor:
        1) Greater than 0.98 for primary lamp.

2) Greater than 0.90 throughout the dimming range for primary lamp.
g. Ballast factor: 1.0 at maximum light output.
h. Minimum starting temperature:
1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or specified in Section 16050:
a) For compact fluorescent lamps: 10 degrees Celsius (50 degrees Fahrenheit).
i. Sound rating: Class A or quieter.
j. Total harmonic distortion of the input current less than 10 percent.
k. Tolerate sustained open circuit and short circuit output conditions without damage.
l. High efficiency and meet all US state and federal efficacy laws.
m. Use dimming ballasts with dimmer controlled fluorescent fixtures where indicated on the Drawings.
n. Rated for location of installation.
4. Ballasts for high intensity discharge lamps:
a. Meet requirements of UL 1029.
b. Input power source:
1) As indicated on the Drawings.
c. With sustained variations of within 10 percent (voltage and frequency) with no change to the ballast.
d. Minimum starting temperature:
1) Unless otherwise indicated on the Drawings, or on the Luminaire Schedule, or specified in Section 16050.
a) High pressure sodium: -40 degrees Celsius.
b) Metal halide lamps: -30 degrees Celsius.
e. Power factor: greater than 0.90.
f. Provide pulse start ballasts with a minimum efficiency of 88 percent for metal halide lamps.
g. Core and coil ballast with class “H” (180 degree Celsius) or higher insulation system and vacuum-pressure impregnated with silica-filled polyester resin:
1) Copper windings.
2) Internally fused.
h. Ballast factor: 1.0.

2.06 COMPONENTS

A. Luminaire poles:
1. As indicated on the Luminaire Schedule.
2. Anchor bolts:
a. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic and wind forces.
1) Standard hex bolt head.
2) Do not use anchor bolts fabricated from rod stock with an L or J-shape.
b. Complete with leveling shims.
3. Anchor base:
a. Fabricated from the same type of material as the pole shaft.
b. Base plate to telescope the pole shaft.
c. Welded top and bottom along the entire perimeter.
d. With slotted boltholes on the bolt circles as submitted.

4. Pole shaft:
    a. As indicated on the Luminaire Schedule.
5. Handhole:
    a. Reinforced handhole located approximately 18 inches above the base.
    b. Complete with cover fabricated from the same material as the pole shaft and stainless steel attachment screws.
    c. With an integral ground connection nut, 1/2 inch by 13 inch UNC welded to the pole for connection to the grounding system.
6. Shroud:
    a. Fabricated from the same type of material as the pole shaft.
    b. 1-piece formed channel section that shall conform to the pole shaft taper.
    c. Secured by a locking device with provisions for a padlock to prevent accidental lowering.
7. Fastening hardware:
    a. All fasteners shall be stainless steel.
8. Finish:
    a. As indicated on the Luminaire Schedule.

2.07 ACCESSORIES

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install luminaires per the manufacturer's guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.

C. Special techniques:
    1. Support luminaires from structural elements capable of carrying the total weight.
    2. Install luminaires plumb and square with building and wall intersections:
        a. Suspend pendant-mounted luminaries that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
        b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or duct work.
    3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:

a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.

4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.
5. Provide ceiling or pendent mounted HID luminaires with a safety chain connecting the lens, reflector, ballast and other components to the building structure.
6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
   a. The safety supports shall consist of number 12 AWG soft drawn galvanized wires.
7. Install luminaires in accordance with the architectural reflected ceiling Drawings:
   a. Center luminaires on ceiling tiles unless otherwise indicated.
8. Support luminaires installed in suspended grid ceilings, independently of the grid:
   a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.

D. Luminaire poles:
   1. Set poles on anchor bolts and secured with double nuts on each bolt.
   2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
   3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole:
      a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.09 CLEANING

A. As specified in Section 16050.

B. Clean all lenses, diffusers, and reflectors.

C. Refinish all luminaire’s trim, poles and support brackets, where finish has been damaged.

D. Clean and re-lamp all luminaires (new and old), used during construction for construction lighting, before substantial completion.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.
   1. Perform the lighting demonstration, in accordance with this Section, witnessed by the Owner and the Engineer. The entire lighting system shall be observed to verify luminaires are properly focused and aimed.
   2. Switching functions are in accordance with the Contract Documents and verify all:
      a. Photocell operation.
      b. Time clock operation.
      c. Programmable lighting control operations.
      d. Switching operations.
      e. Dimming operations.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 16920

PRECAST CONCRETE WALK-IN ELECTRICAL ENCLOSURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Precast concrete walk-in electrical enclosures, completely engineered, assembled, and installed. This is an alternate to the CMU Electrical Buildings shown on plans at Well Sites Nos. 1 & 2.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01230 - Alternates.
      b. Section 01330 - Submittal Procedures.
      c. Section 01410 - Regulatory Requirements.
      d. Section 01756 - Commissioning and Process Start-up.
      e. Section 03300 - Cast-In-Place Concrete.
      f. Section 03410 - Precast Concrete Enclosure.
      g. Section 16050 - Common Work Results for Electrical.
      h. Section 16123 - 600-Volt or Less Wires and Cables.
      i. Section 16130 - Conduits.
      j. Section 16140 - Wiring Devices.
      k. Section 16500 - Lighting.

1.02 REFERENCES

A. As specified in Section 16050.

B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 210/240 - Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.
   2. 270 - Sound Rating of Outdoor Unitary Equipment.
   3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

C. Air Moving and Conditioning Association International, Inc. (AMCA):
   1. Standard 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

D. American Society of Heating, Refigerating and Air-Conditioning Engineers, Inc, (ASHRAE):
   1. Standard 15 - Safety Standard for Refrigeration Systems.
   2. Standard 52.2 - Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.
   3. Standard 62 - Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings.

E. American Concrete Institute:
   1. ACI 318-11: Building Code Requirements for Concrete.

F. Precast Concrete Institute:
   1. Manuals of Standard Practice.

G. ASTM International (ASTM):
   1. A 84 - Standard Test MEthod for Surface Burning Characteristics of Building Materials.

H. National Electrical Manufacturer's Association (NEMA):
   1. NEMA Type TEFC enclosure in accordance with NEMA 250.

I. National Fire Protection Association:
   1. NFPA 70 - National Electric Code (NEC).
   2. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

J. Steel Structures Painting Council (SSPC):
   1. SP-1 - Solvent Cleaning.
   2. SP-2 - Hand Tool Cleaning.
   3. SP-3 - Solvent Cleaning.

K. Underwriters Laboratories Inc. (UL).

1.03 DEFINITIONS

A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Designed and environmentally controlled to provide protection to all equipment it contains under the specified Project Site conditions.
      a. Size the enclosure to accommodate the actual equipment furnished including all Code required clearances and access.
   2. Enclosure shall not be smaller in footprint than the structure shown on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. Furnish submittals for all electrical equipment contained within the enclosure as required by the section covering the equipment.

C. Product data:
   1. Manufacturer of enclosure.
   2. Manufacturer of component parts of enclosure.
   3. Weight of enclosure.
   4. Complete bill of material indicating quantity, description, and part number.
   5. Anchorage hardware.
   6. Enclosure infrastructure, including but not limited to:
      a. Lighting fixtures.
      b. Receptacles.
      c. Raceways.
      d. Wire.
      e. Data and telecom jacks.
      f. HVAC equipment.

D. Shop drawings:
   1. Layout drawings:
      a. Provide fully dimensioned and to scale equipment layout drawings which include:
         1) Enclosure plan view including layout of internal equipment.
         2) Enclosure elevations of front, back and both sides.
         3) Enclosure base plan including slab details, cable entry areas and floor openings, and door swing requirements.
   2. Wiring diagrams:
      a. Provide detailed raceway layout and wiring diagrams for all interconnections within the enclosure, including conduit sizes and wire fill.

E. Installation instructions:
   1. Provide written instructions detailing the complete installation of the enclosure, including rigging, moving, setting into place, and combination of shipping splits where applicable.
   2. Provide complete instructions and requirements for anchoring the enclosure to meet the seismic requirements at the Project Site as specified in Section 16050:
      a. Instructions and requirements must be stamped by a professional engineer licensed in the state where the Project is being constructed.

F. Calculations:
   1. Provide complete structural calculations indicating that the enclosure, anchorage, and cast-in-place structural pad are suitable for the seismic and wind requirements at the project site:
      a. Calculations must be stamped by a professional engineer licensed in the state where the Project is being constructed.
      b. Indicate pick-up points, strong backs, lifting inserts, and all reinforcing.
   2. Provide complete heating and cooling calculations indicating that the HVAC system supplied will maintain the internal enclosure temperature specified in this Section under the Project/Site Conditions as specified in Section 16050.
   3. Provide complete lighting calculations indicating that the lighting system provided meets the requirements specified in this Section.

G. Provide samples of available interior metal liner or FRP panels finish colors to Owner for selection.

H. Additional Requirements:
   1. As specified in Section 03410 - Precast Concrete Enclosure.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. The manufacturer of the enclosure shall be ISO 9001 certified.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050.

1.08 PROJECT/SITE CONDITIONS

A. As specified in Section 16050.

B. Environmental requirements:
   1. Provide enclosures that are suitable for operation under the project site conditions specified in the Contract Documents, including, but not limited to, material compatibility, site altitude, site seismic, ambient temperature, and humidity conditions.

1.09 SEQUENCING

A. Do not install conduit or ductbanks that will enter the enclosure from below until final approval of the enclosure submittal.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

B. Extended warranty:
   1. Provide an additional ten year(s) manufacturer's warranty for all equipment provided under this Section.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Old Castle Precast, Chandler, Arizona.

2. Utility Concrete Products, Morris, Illinois.
3. Lonestar Prestress, Houston, Texas.
4. or equal, certified by Precast Concrete Institute (PCI).

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Concrete roof, wall, and floor construction; self-supporting and freestanding. Free from noticeable deflection, discoloration, rock pockets, or other visible defects.
   2. Monolithic concrete reinforced in accordance with ACI 318.

B. Floor:
   1. Cast-in-place constructed as shown on current plan.
   2. Provide wall anchors where bottom access is required for electrical equipment, provide floor cutouts with gasketed removable 12-gauge galvanized steel cover plates in the cast-in-place slab. And as shown on plant for the precast enclosure.

C. Walls:
   1. Constructed with an exterior wall of minimum 7" thick concrete reinforced in accordance with ACI 318..
   2. Where wall penetrations are required, cutouts shall be neatly framed by coverplates with neoprene gaskets.

D. Enclosure roof and ceiling:
   1. Elastomeric, crack-proof roof covering that is waterproof and weather-tight under all circumstances of inclement weather.
   2. Enclosures shall be constructed with a concrete roof panel of minimum 7" thickness reinforced in accordance with ACI 318.
   3. The roof shall be designed to withstand a minimum live load of 40 pounds per square foot, and shall be designed to support interior and exterior equipment loads without compromising roof load design.
   4. Where roof penetrations are required, provide flashing, adequately sealed, to maintain the weatherproof integrity of the roof.

E. Insulation and Interior Finish:
   1. Walls shall be insulated to a minimum of R-13 and the roof shall be insulated to a minimum R-30 using rigid insulation installed between the inner face of the precast concrete panels and the exposed metal liner or FRP panels.
   2. The interior metal liner or FRP panels shall be attached to z-furring wall framing and fastened to the concrete with fasteners or anchors to penetrate substrate as recommended by manufacturer.

F. Doors:
   1. Hollow Metal Doors and Frames and Door Hardware:
      a. Reference sections 08110 and 08710.

G. Wiring and raceways:

1. Wire and cable as specified in Section 16123.
2. Use one of the following raceway types to route wiring within the enclosure:
    a. Conduit as specified in Section 16130.

H. Lifting Inserts: Minimum factor of safety of 3.

2.05 EQUIPMENT

A. Furnish, install, and test all equipment within the enclosure in conformance with the applicable equipment section.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. HVAC system:
1. Provide an HVAC system designed to maintain an ambient temperature of between 50 and 90 degrees Fahrenheit under the worst case site conditions specified in [Section 16050].
2. Mounted to the wall or roof of the enclosure.
3. HVAC equipment shall operate at 480 V, 3-phase and shall include a lockable circuit breaker or disconnect switch. It is the responsibility of the enclosure supplier to ensure that the overcurrent protection for all HVAC equipment is sized in accordance with NEC.
4. Provide units in one piece, factory assembled, piped, internally wired, charged with refrigerant and compressor oil, and tested.
5. Design requirements:
    a. Electrical components: UL listed and met the design and installation requirements of the NEC.
    b. Gas, water piping, drains, and venting: In accordance with building code, mechanical code, and plumbing code as specified in Section 01410 and in accordance with NFPA 90A.
    c. Fans: Rated in accordance with AMCA 210.
    d. Unit air conditioners: Rated in accordance with AHRI Standards 210/240 or 340/360 and AHRI 270. In accordance with the latest version of ASHRAE 15.
    e. Energy efficiency ratio (EER) of 10.3 as rated in accordance with AHRI 210/240 or 340/360 and 270.
6. Compressors:
    a. Fully hermetically sealed, high efficiency, reciprocating or rotary or scroll type, with rubber grommet vibration isolation.
    b. Utilize HFC-134a or HFC -410a as the refrigerant.
7. Fans:
    a. Indoor air fan:
        1) Direct driven with capacitor start motor: Fan centrifugal type, steel with corrosion resistant finish, statically and dynamically balanced.
        2) Bearings: Permanently sealed ball bearing type and permanently lubricated.
    b. Outdoor condenser fan:
        1) Propeller type, direct drive, aluminum blades, dynamically balanced.
        2) Bearings: Permanently sealed ball bearing type and permanently lubricated.

8. Coils:
    a. Evaporator and condenser coils: Seamless copper tubes with mechanically bonded aluminum plate fins.
9. Refrigerant components: Refrigerant circuit including:
    a. Accumulator and filter/drier.
    b. Expansion device.
    c. Flow control valves.
    d. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.
10. Controls:
    a. Provide system controls for a complete functioning system controlled by an electronic, automatic changeover thermostat. Thermostat shall be mounted on an insulated backing plate.
11. Electrical:
    a. Provide for single external power connection.
12. Unit casing:
    a. Slide out design unit casing manufactured galvanized steel with electrically bonded finish and outdoor components top coated with high solids polyester finish.
    b. Weatherproof design, reinforced and braced for maximum rigidity.
    c. Provided with:
        1) Filter rack for filters accessible through the front of the unit.
        2) Non-corrosive drain pan in accordance with ASHRAE Standard 62.
        3) Horizontal drain connection.
        4) Knockouts for power connections.
        5) Provide wall sleeve of galvanized steel coated similar to unit casing.
13. Air filters: 25 to 30 percent efficiency when rated in accordance with ASHRAE Standard 52.2.
14. Extra materials:
    a. Provide 2 extra sets of filters per unit installed.

B. Lighting:
1. Interior lighting:
    a. Provide a lighting system capable of producing 40 foot candles of light at a level 3 feet above enclosure floor at the end of the expected lamp life.
    b. Industrial grade, totally enclosed, fully gasketed 2-lamp T-8 fixtures, UL listed for damp locations.
        1) Operating voltage: 240 V.
    c. Provide light switches as indicated on the Drawings to control interior light fixtures.
2. Emergency lighting:
    a. Provide an industrial grade emergency lighting fixture with thermoplastic enclosure, 12-volt nickel cadmium battery, and minimum 90-minute operating capacity, mounted above each exterior door.
3. Exterior lighting:
    a. Provide an industrial grade, 70W high pressure sodium wall pack fixture with IES cutoff distribution, UL listed for wet locations, mounted above each exterior door.
    b. Exterior lighting fixtures shall be automatically controlled by a photocell.
4. Provide lighting equipment as specified in Section 16500.

C. Receptacles:

1. Provide receptacles installed and tested by the enclosure supplier, located as indicated on the Drawings.
2. Provide receptacles as specified in Section 16140.

D. Padlocks:
1. Master Lock or equal.
2. Provide for each individual access door:
3. Weather-resistant, rated for outdoor use.
4. Single-keyed.
   a. Furnish 2 keys for each lock.
5. Provide 2 spare padlocks and associated keys.

2.08 MIXES

A. Class D concrete in accordance with specification Section 03300.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. General:
1. Thoroughly clean and prepare all surfaces according to SSPC-SP-1 and either SSPC-SP-2 or SSPC-SP-3, as required to remove all oil, grease, soil, rust, and scale before applying any coatings or paint.

B. Floor:
1. Provide broom or burlap non-skid surface.

C. Shop Finishing Exterior walls:
   a. After casting and removing forms, rework and rub to obtain smooth, uniform texture.
   b. Exterior surfaces should receive F3 finish and be prepared for painting as specified in Section 09910.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Install the enclosure per manufacturer’s guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Any components or concrete damaged during installation shall be replaced.

D. Install enclosures so that their surfaces are plumb and level within 1/8 inch over their entire base.

E. Install gasket and sealing material under enclosures with floor slab cutouts for conduit and cables to prevent entry of dust, debris, or vermin into the enclosure and equipment contained therein.

3.04 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 01756.

3.05 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.06 ADJUSTING

A. Pressure-inject cracks or structural damage due to any cause.

B. Patch damaged areas to match adjacent concrete and re-finish entire wall affected.

3.07 CLEANING

A. As specified in Section 16050.

3.08 PROTECTION

A. As specified in Section 16050.

END OF SECTION

SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Routine tests during installation.
   3. Adjusting and calibration.
   4. Acceptance tests.
   5. Demonstration of electrical equipment.
   6. Commissioning and plant start-up.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050 - Common Work Results for Electrical.
      c. Section 16060 - Grounding and Bonding.

C. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. As specified in Section 16050.

B. American National Standards Institute (ANSI).

C. ASTM International (ASTM):
   1. D 877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   2. D 923 - Standard Practices for Sampling Electrical Insulating Liquids.
   3. D 971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   4. D 1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   5. D 1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).

6. D 1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
7. D 1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
8. D 3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

D. Institute of Electrical and Electronics Engineers (IEEE):
1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
4. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
5. C57.13 - IEEE Standard Requirements for Instrument Transformers.
6. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
7. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
8. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

E. Insulated Cable Engineer's Association (ICEA).

F. InterNational Electrical Testing Association (NETA).
1. ATS-2009 Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

G. International Electrotechnical Commission (IEC).

H. Manufacturer's testing recommendations and instruction manuals.

I. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
2. 110 - Standard for Emergency and Standby Power Systems.

J. National Institute of Standards and Technology (NIST).

K. Specification sections for the electrical equipment being tested.

L. Shop drawings.

1.03 DEFINITIONS

A. As specified in Section 16050.

B. Specific definitions:
1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative:
   1. The Engineer will witness all visual, mechanical and electrical tests and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications. The results of the tests shall determine the suitability for continued reliable operation.

D. Responsibilities:
   1. Contractor responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.
      d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
         1) Providing electrical power as required.
         2) Operating of electrical equipment in conjunction with testing of other equipment.
         3) Activating and shutting down electrical circuits.
         4) Making and recording electrical measurements.
         5) Replacing blown fuses.
         6) Installing temporary jumpers.
   3. Testing laboratory responsibilities:
      a. Perform all acceptance tests as defined in this Section.
      b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

E. Upon completion of testing or calibration, attach a label to all serviced devices:
   1. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 16050.

B. LAN cable test form:
   1. LAN cable test reports:
      a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
         1) Test type.
         2) Test location.
         3) Test date.
         4) Cable number.

5) Cable length.
6) Certification that the cable meets or exceeds the specified standard.

b. Furnish hard copy and electronic copy for all traces.

C. Test report:
1. Include the following:
a. Summary of Project.
b. Description of equipment tested.
c. Description of tests performed.
d. Test results.
e. Conclusions and recommendations.
f. Completed test forms.
g. List of test equipment used and calibration dates.
h. LAN cable test reports.

D. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

E. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

F. Manufacturers' testing procedures:
1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050.

B. Testing laboratory qualifications:
1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050.

1.09 SEQUENCING

A. Perform testing in the following sequence:
1. Perform routine tests as the equipment is installed including:

a. Insulation resistance tests.
b. Continuity tests.
c. Rotational tests.

2. Adjusting and preliminary calibration.
3. Acceptance tests.
4. Demonstration.
5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. Commissioning and plant start-up, as described in the Specifications, shall not begin until acceptance testing is complete, and operation has been demonstrated to the satisfaction of the Engineer.

B. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable:
   1. Simulation of process parameters will be considered only upon receipt of a written request by the Contractor.

C. Record all motor currents during normal operation.

D. Record the indications of all power meters every half-hour during commissioning.

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. General:
   1. Test instrument calibration:
      a. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
      b. The accuracy shall be traceable to the NIST in an unbroken chain.
      c. Calibrate instruments in accordance with the following frequency schedule:
         1) Field instruments: 6 months maximum.
         2) Laboratory instruments: 12 months maximum.
         3) Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
      d. Dated calibration labels shall be visible on all test equipment.
      e. Maintain an up-to-date instrument calibration record for each test instrument:
         1) The records shall show the date and results of each calibration or test.
      f. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Do not begin testing until the following conditions have been met:
   1. All instruments required are available and in proper operating condition.
   2. All required dispensable materials such as solvents, rags, and brushes are available.
   3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
   4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
   5. Data sheets to record all test results are available.

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Switchboard:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding and required area clearances.
      d. Inspect equipment for cleanliness.
      e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
      f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.
      g. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      h. Mechanical and electrical interlocks:
         1) Attempt closure on locked-open devices.
         2) Attempt to open locked-closed devices.
         3) Make/attempt key-exchanges in all positions.
      i. Lubrication requirements:
         1) Verify appropriate lubrication on moving current-carrying parts.
         2) Verify appropriate lubrication on moving and sliding surfaces.
      j. Inspect insulators for evidence of physical damage or contaminated surfaces.
      k. Verify correct barrier and shutter installation and operation.
      l. Exercise all active components.
      m. Inspect all indicating devices for correct operation.
      n. Verify that filters are in place and/or vents are clear.
      o. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
      p. Inspect control power transformers:
         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
         3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable.
      b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute.
         1) Perform test in accordance with NETA ATS tables.
      c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with

manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
    1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
e. Perform electrical tests on instrument transformers as specified in this Section.
f. Perform ground-resistance tests:
    1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
g. Determine the accuracy of all meters.
h. Control power transformers:
    1) Perform insulation resistance tests. Perform measurements from winding-to-winding and each winding-to-ground:
        a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
    2) Perform secondary wiring integrity test:
        a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
            (1) Verify correct potential at all devices.
    3) Verify correct secondary voltage by energizing primary winding with system voltage:
        a) Measure secondary voltage with the secondary wiring disconnected.
i. Voltage transformers:
    1) Perform secondary wiring integrity test:
        a) Verify correct potential at all devices.
    2) Verify correct secondary voltage by energizing primary winding with system voltage.
j. Perform current injection tests on the entire current circuit of each switchgear or switchboard:
    1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:
        a) Verify the correct magnitude of current at each device in the circuit.
k. Perform system function tests.
l. Verify operation of space heaters.

3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
    d. Compare bus connection resistances to values of similar connections.

1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Investigate insulation values less than the allowable minimum.
c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

e. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
f. Insulation-resistance values for control wiring shall not be less than 2 megohms.
g. Instrument transformer test values as specified in this Section.
h. Investigate grounding system resistance values that exceed 0.5 ohm.
i. Meter accuracy shall be in accordance with manufacturer's published data.
j. Control power transformers:
1) Insulation resistance values of control power transformers shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Investigate insulation values less than the allowable minimum.
c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
2) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
3) Secondary voltage shall be as indicated on the Drawings.
k. Voltage transformers:
1) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
2) Secondary voltage shall be as indicated on the Drawings.
l. Current-injection tests shall prove current wiring is as indicated on the Drawings and specified in the Specifications.
m. Results of system function tests shall match the Drawings and Specifications.
n. Heaters shall be operational.

B. Cables, 600 volts and less:
1. Visual and mechanical inspection:
a. Compare cable data with that indicated on the Drawings and specified in the Specifications.
b. Inspect exposed sections of cables for physical damage and correct connection as indicated on the Drawings.
c. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

3) Thermographic survey.
d. Inspect compression-applied connectors for correct cable match and indentation.
e. Inspect for correct identification and arrangements.
f. Inspect jacket insulation and condition.

2. Electrical tests:
a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
b. Perform insulation-resistance tests on each conductor with respect to ground and adjacent conductors:
1) Applied voltage shall be:
a) 500 VDC for 300-volt rated cable.
b) 1,000 VDC for 600-volt rated cable.
2) Test duration shall be 1 minute.
c. Perform continuity tests to ensure correct cable connection.
d. Verify uniform resistance of parallel conductors.

3. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
d. Insulation resistance values shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
2) Investigate values of insulation resistance less than the allowable minimum.
e. Cables shall exhibit continuity.
f. Investigate deviations in resistance between parallel conductors.

C. Low voltage molded case and insulated case circuit breakers:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage and alignment.
d. Verify the unit is clean.
e. Operate circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance by one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.

g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
   b. Perform insulation resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
      1) Apply voltage in accordance with manufacturer's published data.
      2) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Perform a contact/pole-resistance test.
   d. Determine long-time pickup and delay by primary current injection.
   e. Determine short-time pickup and delay by primary current injection.
   f. Determine ground-fault pickup and delay by primary current injection.
   g. Determine instantaneous pickup value by primary current injection.
   h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
   i. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function and trip unit battery condition:
      1) Reset all trip logs and indicators.
   j. Verify operation of charging mechanism.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   d. Insulation resistance values shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      2) Investigate values of insulation resistance less than the allowable minimum.
   e. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
      1) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   f. Insulation resistance values of control wiring shall not be less than 2 megohms.
   g. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:

1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.

h. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

i. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

j. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.

k. Pickup values and trip characteristics shall be within manufacturer's published tolerances.

l. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:
   1) Refer to NETA ATS tables in the absence of manufacturer's published data.

m. Breaker open, close, trip, trip-free, antipump, and auxiliary features shall function as designed.

n. The charging mechanism shall operate in accordance with manufacturer's published data.

D. Metering devices:

1. Visual and mechanical inspection:
   a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
         a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   d. Thermographic survey.
   e. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts as applicable.
   f. Verify the unit is clean.
2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Verify accuracy of meter at all cardinal points.
   c. Calibrate meters in accordance with manufacturer's published data.
   d. Verify that current transformer, and voltage transformer secondary circuits are intact.
3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:

1) Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
d. Meter accuracy shall be in accordance with manufacturer's published data.
e. Calibration results shall be within manufacturer's published tolerances.
f. Instrument multipliers shall be in accordance with system design specifications.
g. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

E. Grounding systems:
1. Visual and mechanical inspection:
a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the National Electrical Code.
b. Inspect physical and mechanical condition.
c. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect anchorage.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
3. Test values:
a. Grounding system electrical and mechanical connections shall be free of corrosion.
b. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
c. Bolt torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
d. The resistance between the main grounding electrode and ground shall be as specified in Section 16060. Investigate point-to-point resistance values that exceed 0.5 ohm.

F. Rotating machinery:
1. Visual and mechanical inspection:
a. Compare equipment nameplate information with that indicated on the Drawings and specified in the Specifications.

b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
e. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
        b) Thermographic survey.
f. Perform special tests such as gap spacing and machine alignment if applicable.
g. Verify correct application of appropriate lubrication and lubrication systems.
h. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
    b. Perform insulation resistance test in accordance with IEEE 43:
        1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.
        2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
    c. Perform dc dielectric withstand voltage tests on machines rated at 2,300 volts and greater in accordance with IEEE 95.
    d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
    e. Perform insulation resistance test on insulated bearings in accordance with manufacturer's published data.
    f. Test surge protection devices as specified in this Section.
    g. Test motor starter as specified in this Section.
    h. Perform resistance tests on resistance temperature detector (RTD) circuits.
    i. Verify operation of motor space heater.
    j. Perform a rotation test to ensure correct shaft rotation.
    k. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
3. Test values:
    a. Inspection:
        1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
        2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
        3) Cooling fans shall operate.
        4) Slip ring alignment shall be within manufacturer's published tolerances.
        5) Brush alignment shall be within manufacturer's published tolerances.
        6) Brush rigging shall be within manufacturer's published tolerances.

b. Compare bolted connection resistance values to values of similar connections:
    1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
c. Bolt-torque levels shall be in accordance with manufacturer's published data:
    1) Refer to NETA ATS tables in the absence of manufacturer's published data.
d. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
e. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
f. The dielectric absorption ratio or polarization index shall not be less than 1.0. The recommended minimum insulation ($IR_{1\ min}$) test results in megohms shall be corrected to 40 degrees Celsius and read as follows:
    1) IR1 min equals 100 megohms for dc armature and ac windings with form-wound coils above 1 kilovolt.
    2) IR1 min equals 5 megohms for machines and random-wound stator coils and form-wound coils rated below 1 kilovolt.
        a) Dielectric withstand voltage and surge comparison tests shall not be performed on machines having lower values than those indicated above.
g. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
h. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
i. Power factor or dissipation factor values shall be compared to manufacturer's published data:
    1) In the absence of manufacturer's published data compare values of similar machines.
j. Tip-up values shall indicate no significant increase in power factor.
k. If no evidence of distress, insulation failure or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
l. Bearing insulation resistance measurements shall be within manufacturer's published tolerances:
    1) In the absence of manufacturer's published data compare values of similar machines.
m. Test results of surge protection devices shall be as specified in this Section.
n. Test results of motor starter equipment shall be as specified in this Section.
o. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
p. Heaters shall be operational.
q. Vibration amplitudes shall not exceed values in NETA ATS tables:
    1) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
r. Machine rotation should match required rotation of connected load.

s. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.

G. Motor control centers, low voltage:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding and required clearances.
d. Inspect equipment for cleanliness.
e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and coordination study.
f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.
g. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.
h. Mechanical and electrical interlocks:
1) Attempt closure on locked-open devices.
2) Attempt to open locked-closed devices.
3) Make/attempt key-exchanges in all positions.
i. Lubrication requirements:
1) Verify appropriate lubrication on moving current-carrying parts.
2) Verify appropriate lubrication on moving and sliding surfaces.
j. Inspect insulators for evidence of physical damage or contaminated surfaces.
k. Verify correct barrier and shutter installation and operation.
l. Exercise all active components.
m. Inspect all indicating devices for correct operation.
n. Verify that filters are in place and/or vents are clear.
o. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
p. Inspect control power transformers:
1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
q. Perform visual and mechanical inspection of circuit breakers as specified in this Section.
r. Perform visual and mechanical inspection of starters as specified in this Section.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable.

b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
    1) Perform test in accordance with NETA ATS tables.
c. Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
d. Perform ground-resistance tests:
    1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
e. Determine the accuracy of all meters.
f. Control power transformers:
    1) Perform insulation resistance tests, winding-to-winding and winding-to-ground:
        a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
    2) Perform secondary wiring integrity test:
        a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
            (1) Verify correct potential at all devices.
    3) Verify correct secondary voltage by energizing primary winding with system voltage:
        a) Measure secondary voltage with the secondary wiring disconnected.
g. Verify operation of space heaters.
h. Perform electrical tests of circuit breakers as specified in this Section.
i. Perform electrical tests of starters as specified in this Section.

3. Test values:
    a. Compare bus connection resistances to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
    d. Compare bus connection resistances to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:
            a) Refer to NETA ATS tables in the absence of manufacturer's published data.
            b) Investigate insulation values less than the allowable minimum.
            c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
    e. Bus insulation shall withstand the overpotential test voltage applied.
    f. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
    g. Instrument transformer test values shall be as specified in this Section.

h. Investigate grounding system resistance values that exceed 0.5 ohm.
i. Meter accuracy shall be in accordance with manufacturer's published data.
j. Control power transformers:
1) Insulation resistance values of control power transformers shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Investigate insulation values less than the allowable minimum.
c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
2) Secondary wiring shall be in accordance with that indicated on the Drawings and specified in the Specifications.
3) Secondary voltage shall be in accordance with that indicated on the Drawings.
k. Heaters shall be operational.
l. Test values for circuit breakers shall be as specified in this Section.
m. Test values for starters shall be as specified in this Section.

H. Variable frequency drive systems:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
g. Motor running protection:
1) Verify drive overcurrent setpoints are correct for their application.
2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
h. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.
i. Verify correct fuse sizing in accordance with manufacturer's published data.
j. Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.

b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
c. Test for the following parameters in accordance with relay calibration procedures specified in this Section or as recommended by the manufacturer:
1) Input phase loss protection.
2) Input overvoltage protection.
3) Output phase rotation.
4) Overtemperature protection.
5) Direct current overvoltage protection.
6) Overfrequency protection.
7) Drive overload protection.
8) Fault alarm outputs.
d. Perform continuity tests on bonding conductors as specified in this Section.
e. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
f. Perform operational tests by initiating control devices:
1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
2) Verify operation of drive from remote start/stop and speed control signals.
g. Perform electrical tests of input circuit breaker as specified in this Section.

3. Test values:
a. Compare bolted connection resistances to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
d. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
e. Test values for input circuit breaker shall be as specified in this Section.
f. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
g. Relay calibration results shall be as specified in this Section.
h. Continuity of bonding conductors shall be as specified in this Section.
i. Control devices shall perform in accordance with system requirements.
j. Operational tests shall conform to system design requirements.

I. Surge arresters, low-voltage:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.

e. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
h. Record stroke counter reading.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
        1) Apply voltage in accordance with manufacturers published data.
        2) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Test grounding connection as specified in this Section.
3. Test values:
    a. Compare bolted connection resistances to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Insulation resistance values shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        2) Investigate insulation values less than the allowable minimum.
    d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

J. Engine generator:
1. Visual and mechanical inspection:
    a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the unit is clean.
2. Electrical and mechanical tests:
    a. Perform insulation-resistance tests in accordance with IEEE 43:
        1) Machines larger than 150 kilowatts: Test duration shall be 10 minutes. Calculate polarization index.
        2) Machines 150 kilowatts and less: Test duration shall be 1 minute. Calculate the dielectric-absorption rate.
    b. Test protective relay devices as specified in this Section.

c. Verify phase rotation, phasing, and synchronized operation as required by the application.
d. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
e. Perform vibration test for each main bearing cap.
f. Conduct performance test in accordance with NFPA 110.
g. Verify correct functioning of governor and regulator.

3. Test values:
   a. Anchorage, alignment, and grounding should be in accordance with manufacturer's published data and system design.
   b. The dielectric absorption ratio or polarization index shall be compared to previously obtained results and should not be less than 1.0. The recommended minimum insulation ($IR_{1\ min}$) test results in megohms shall be corrected to 40 degrees Celsius and read as follows:
      1) $IR_{1\ min}$ equals kilovolt + 1 for most windings made before 1970, all field windings, and others not described below.
         a) kilovolt is the rated machine terminal-to-terminal voltage in rms kilovolt.
      2) $IR_{1\ min}$ equals 100 megohms for most dc armature and ac windings built after 1970 (form-wound coils).
      3) $IR_{1\ min}$ equals 5 megohms for most machines and random-wound stator coils and form-wound coils rated below 1 kilovolt.
         a) Dielectric withstand voltage and surge comparison tests shall not be performed on machines having lower values than those indicated above.
   c. Protective relay device test results shall be as specified in this Section.
   d. Phase rotation, phasing, and synchronizing shall be in accordance with system design requirements.
   e. Low oil pressure, overtemperature, overspeed, and other protection features shall operate in accordance with manufacturer's published data and system design requirements.
   f. Vibration levels shall be in accordance with manufacturer's published data and shall be compared to baseline data.
   g. Performance tests shall conform to manufacturer's published data and NFPA 110.
   h. Governor and regulator shall operate in accordance with manufacturer's published data and system design requirements.

K. Uninterruptible power systems:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required clearances.
      d. Verify that fuse sizes and types correspond to that indicated on the Drawings.
      e. Verify the unit is clean.
      f. Test all electrical and mechanical interlock systems for correct operation and sequencing.
      g. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method:
   a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
3) Thermographic survey.

h. Verify operation of forced ventilation.
i. Verify that filters are in place and/or vents are clear.

2. Electrical tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Test static transfer from inverter to bypass and back. Use normal load, if possible.
   c. Set free running frequency of oscillator.
   d. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
   e. Test alarm circuits.
   f. Verify synchronizing indicators for static switch and bypass switches.
   g. Perform electrical tests for UPS system breakers as specified in this Section.
   h. Perform electrical tests for UPS system automatic transfer switches as specified in this Section.
   i. Perform electrical tests for UPS system batteries as specified in this Section.
   j. Perform electrical tests for UPS rotating machinery as specified in this Section.
3. Test values:
   a. Electrical and mechanical interlock systems shall operate in accordance with system design requirements.
   b. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
   e. Static transfer shall function in accordance with manufacturer's published data.
   f. Oscillator free running frequency shall be within manufacturer's published tolerances.
   g. Direct current undervoltage shall trip inverter input breaker.
   h. Alarm circuits shall operate in accordance with design requirements.
   i. Synchronizing indicators shall operate in accordance with design requirements.
   j. Breaker performance shall be as specified in this Section.
   k. Automatic transfer switch performance shall be as specified in this Section.
   l. Battery test results shall be as specified in this Section.
   m. Rotating machinery performance shall be as specified in this Section.

L. Automatic transfer switches:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required clearances.
      d. Verify the unit is clean.
      e. Lubrication requirements:
         1) Verify appropriate lubrication on moving current-carrying parts.
         2) Verify appropriate lubrication on moving and sliding surfaces.
      f. Verify that manual transfer warnings are attached and visible.
      g. Verify tightness of all control connections.
      h. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
         3) Thermographic survey.
      i. Perform manual transfer operation.
      j. Verify positive mechanical interlocking between normal and alternate sources.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with ATS-2009 Section 7.22.3.1.
      b. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Test duration shall be 1 minute:
         1) For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
      c. Perform a contact/pole-resistance test.
      d. Verify settings and operation of control devices.
      e. Calibrate and set all relays and timers as specified in this Section.
      f. Verify phase rotation, phasing, and synchronized operation as required by the application.
      g. Perform automatic transfer tests:
         1) Simulate loss of normal power.
         2) Return to normal power.
         3) Simulate loss of emergency power.
         4) Simulate all forms of single-phase conditions.
      h. Verify correct operation and timing of the following functions:
         1) Normal source voltage-sensing relays.
         2) Engine start sequence.
         3) Time delay upon transfer.
         4) Alternate source voltage-sensing relays.
         5) Automatic transfer operation.
         6) Interlocks and limit switch function.
         7) Time delay and retransfer upon normal power restoration.
         8) Engine cool down and shutdown feature.

3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
    d. Insulation-resistance values of control wiring shall not be less than 2 meghoms.
    e. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
    f. Control devices shall operate in accordance with manufacturer's published data.
    g. Relay test results shall be as specified in this Section.
    h. Phase rotation, phasing, and synchronization shall be as specified in the system design specifications.
    i. Automatic transfers shall operate in accordance with manufacturer's design.
    j. Operation and timing shall be in accordance with manufacturer's and system design requirements.

M. Fiber-optic cables:
    1. Visual and mechanical inspection:
        a. Compare cable, connector, and splice data with that indicated on the Drawings and specified in the Specifications:
        b. Inspect cable and connections for physical and mechanical damage.
        c. Verify that all connectors and splices are correctly installed.
    2. Electrical tests:
        a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
            1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
            2) Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.
        b. Perform connector and splice integrity test using an optical time domain reflectometer.
        c. Perform cable attenuation loss measurement with an optical power loss test set:
            1) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
            2) Test multimode fibers at 850 nanometer and 1,300 nanometer.
            3) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
        d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:

1) At the conclusion of all outdoor splices at one location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.

e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
   1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer and 1,300 nanometer for multimode fibers.
   2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.

3. Test values:
   a. Cable and connections shall not have been subjected to physical or mechanical damage.
   b. Connectors and splices shall be installed in accordance with industry standards.
   c. The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
   d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
   e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

N. LAN cable testing:
   1. Visual and mechanical inspections:
      a. Compare cable type and connections with that indicated on the Drawings and specified in the Specifications.
      b. Inspect cable and connectors for physical and mechanical damage.
      c. Verify that all connectors are correctly installed.
   2. Pre-testing:
      a. Test individual cables before installation:
         1) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
         2) Before the cable is installed, verify that the cable conforms to the manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.
         3) The test shall be fully documented and the results submitted to the Engineer, including a hard copy of all traces, before placement of the cable.
         4) The Engineer shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the Engineer.
   3. Electrical tests:
      a. Perform cable end-to-end testing on all installed cables after installation of connectors from both ends of the cable.

b. Test shall include cable system performance tests and confirm the absence of wiring errors.

4. Test results:
   a. Cables shall meet or exceed TIA standards for a Category 6 installation.
5. Test equipment:
   a. LAN certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
      1) Near end cross talk.
      2) Attenuation.
      3) Equal level far end cross talk.
      4) Return loss.
      5) Ambient noise.
      6) Effective cable length.
      7) Propagation delay.
      8) Continuity/loop resistance.
   b. LAN certification test equipment shall be able to store and produce plots of the test results.
   c. Acceptable manufacturers: The following or equal:
      1) Agilent Technologies, WireScope 350.

3.08 ADJUSTING

A. Adjust limit switches and level switches to their operating points before testing.

B. Set pressure switches, flow switches, and timing relays to anticipated values before testing:
   1. Final settings shall be as dictated by operating results during testing.

3.09 CLEANING

A. As specified in Section 16050.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 16050.

B. Subsystem demonstration:
   1. Subsystem, as used in this Section, means individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, blowers, lighting control systems and other electrically operated or controlled equipment.
   2. Before demonstrating any subsystem:
      a. Demonstrate proper operation of all alarm and status contacts.
      b. Adjust and calibrate all process and control devices as accurately as possible.
   3. Operate each subsystem in its manual mode:
      a. Demonstrate compliance with all Contract requirements.
   4. After each subsystem has operated successfully in its manual mode, perform automatic and remote operation demonstrations:

a. Verify that all features are fully operational and meet all Contract requirements.
b. Demonstrate all operating modes and sequences, including proper start and stop sequence of pumps, proper operation of valves and proper speed control.

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Process Control and Instrumentation Work.
   2. General requirements for process control and instrumentation submittals.
   3. As specified in this Section, all PLC programming and SCADA HMI software configuration will be provided by the Contractor's Programmer, through the services of a consultant, hereinafter referred to as the Programmer.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
      a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Document 00700 - General Conditions.
      b. Document 00800 - Supplementary Conditions.
      c. Section 01140 - Work Restrictions.
      d. Section 01292 - Schedule of Values.
      e. Section 01312 - Project Meetings.
      f. Section 01329 - Safety Plan.]
      g. Section 01330 - Submittal Procedures.
      h. Section 01410 - Regulatory Requirements.
      i. Section 01450 - Quality Control.
      j. Section 01610 - Project Design Criteria.
      k. Section 01756 - Testing, Training, and Facility Start-Up.
      l. Section 01770 - Closeout Procedures.
      m. Section 01782 - Operation and Maintenance Data.
      n. Section 16050 - Common Work Results for Electrical.
      o. Section 16075 - Electrical Identification.
      p. Section 16222 - Low Voltage Motors up to 500 Horsepower.
      q. Section 17100 - Control Strategies.
      r. Section 17101 - Specific Control Strategies.
      s. Section 17761 - PLC Programming Software.
      t. Section 17762 - Control Systems SCADA Software.

u. Section 17950 - Testing, Calibration, and Commissioning.

C. Interfaces to equipment, instruments, and other components:
   1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer's wiring requirements.
   3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents
      c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

D. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
   3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications' requirements.

E. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.

2. Specifications:
    a. Documents 00700 and 00800 of the Contract Documents govern the Work.
    b. These requirements are in addition to all General Requirements.
3. Contract Drawings:
    a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the Drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire Drawing set for construction purposes.
    b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
        1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
        2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
    c. Installation details:
        1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
    d. Schematic diagrams:
        1) All controls are shown de-energized.
        2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
        3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
        4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
        5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

F. Alternates/Alternatives:
   1. Substitute item provisions as specified in Document 00700.

G. Changes and change orders:
   1. As specified in Document 00700.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410:
      a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
   2. The following codes and standards are hereby incorporated into this Section:
      a. American National Standards Institute (ANSI).
      b. American Petroleum Institute (API):
         1) RP 550 – Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
         2) RP 551 - Process Measurement Instrumentation.
      c. International Organization for Standardization (ISO):
         1) 9001 - Quality Management Systems - Requirements.
      d. International Society of Automation (ISA):
         1) 5.1 - Instrumentation Symbols and Identification.
         2) 5.4 - Instrument Loop Diagrams.
         3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
      e. National Electrical Manufacturers Association (NEMA):
         1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
      f. National Fire Protection Association (NFPA).
      g. National Institute of Standards and Technology (NIST).
      h. Underwriters Laboratories, Inc. (UL):
         1) 508 - Standard of Safety for Industrial Control Equipment.
         2) 508A - Standard of Safety for Industrial Control Panels.

B. Compliance with Laws and Regulations:
   1. As specified in Document 00700.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
   1. Factory Mutual (FM).
   2. International Electrotechnical Commission (IEC).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   4. International Society of Automation (ISA).
   5. International Organization for Standardization (ISO).
   6. National Electrical Code (NEC).
   7. National Electrical Manufacturers Association (NEMA).
   8. InterNational Electrical Testing Association (NETA).
   9. National Fire Protection Association (NFPA).
   10. National Institute of Standards and Technology (NIST).

11. Underwriters Laboratories (UL).

B. Specific definitions:
   1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
   2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term “panel” in these Contract Documents is interpreted as a general term, which includes flat surfaces, enclosures, cabinets and consoles.
   3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
   4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
   5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions and diagnostic information.
   6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, two-wire transmitter refers to a transmitter that provides 4 to 20 milliamperes current regulation of a signal in a series circuit with an external 24 VDC driving potential:
      a. Fieldbus communications signal or both.
   7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 milliampere current signal, a digital bus communications signal or both.
   8. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.
   9. Modifications: Changing, extending, interfacing to, removing or altering an existing circuit.

C. NEMA:
   1. Type 1 enclosure in accordance with NEMA 250.
   2. Type 2 enclosure in accordance with NEMA 250.
   3. Type 3 enclosure in accordance with NEMA 250.
   4. Type 3R enclosure in accordance with NEMA 250.
   5. Type 3S enclosure in accordance with NEMA 250.
   6. Type 3X enclosure in accordance with NEMA 250.
   7. Type 3RX enclosure in accordance with NEMA 250.
   8. Type 3SX enclosure in accordance with NEMA 250.
   9. Type 4 enclosure in accordance with NEMA 250.
   10. Type 4X enclosure in accordance with NEMA 250.
   11. Type 5 enclosure in accordance with NEMA 250.
   12. Type 6 enclosure in accordance with NEMA 250.
   13. Type 6P enclosure in accordance with NEMA 250.
   14. Type 12 enclosure in accordance with NEMA 250.
   15. Type 12K enclosure in accordance with NEMA 250.
   16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:

1. CCS: The SCADA central computer system (CCS) consisting of personal computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
2. DPDT: Double-pole, double-throw.
3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
4. FAT: Factory acceptance test.
5. HART: Highway addressable remote transducer.
6. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
7. HMI: Human machine interface: PLC based operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The HMI is typically a flat panel type of display mounted on the front of a PLC enclosure with either a touch screen or tactile button interface.
8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, PLC and SCADA programming, installation, testing, and commissioning of industrial instrumentation and control systems.
9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace or relocate instrument signals.
10. I/O: Input/Output.
11. IP: Internet protocol or ingress protection.
12. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
13. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
14. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
15. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO etc.
16. OIT: Operator interface terminal: PC-based interface device used for operator interface with the SCADA system.

17. P&ID: Process and instrumentation diagram.
18. PC: Personal computer.
19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings.
20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
21. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
22. PLC: Programmable logic controller.
23. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
24. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
25. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and applies operational controls to the process equipment. It includes the PLCs and/or RTUs, HMI PLC-based operator interface units, related interconnecting communications systems, and the CCS operator interface and data management system.
26. SPDT: Single-pole, double-throw.
27. SPST: Single-pole, single-throw.
28. UPS: Uninterruptible power supply.
29. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
30. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the Instrumentation and Control System Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
      a. Preparing hardware submittals for field instrumentation.
      b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
      c. Prepare the test plan, the training plan, and the spare parts submittals.
      d. Procure all hardware.
      e. Provide all PCIS system hardware and software.
      f. Fabricate panels.
      g. Perform factory tests on panels.
      h. Perform bench calibration and verify calibration after installation.
      i. Oversee and certify installation of the PCIS system.
      j. Oversee, document, and certify loop testing.
      k. Oversee, document, and certify system pre-commissioning.
      l. Conduct the performance tests.

m. Prepare operation and maintenance manuals.
n. Conduct training classes.
o. Integrate the PCIS with instrumentation and control devices provided under other sections.
p. Prepare Record Drawings.
    1) Develop all Record Drawings associated with instruments and equipment provided under the
    2) Contract Documents and all Owner furnished and any existing equipment the system is interfacing.
    3) Develop all requisite Record Loop Drawings associated with instruments and equipment provided under the Contract Documents and all Owner furnished and any existing equipment the system is interfacing.
q. Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.
r. Perform all required corrective and preventative maintenance.

2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide the complete operating PCIS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the SCADA requirements.
4. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors or suppliers.
5. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCIS.
6. The Programmer will provide as-built software documentation for the PLCs and computers programmed by the Programmer. The Programmer will provide training on hardware and software items provided by the Programmer. All other documentation and training shall be by the Contractor.
7. The Programmer will provide an additional PLC/HMI software generated events or alarms at the discretion of the Owner, this additions are not to exceed 20 events/alarms.
8. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
9. Defective Work:
    a. As specified in Document 00700.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 and this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Electrical Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 16075 throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Submittal organization:
   1. First page:
      a. Specification section reference.
      b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
      c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
      d. Place for Contractor's review stamp and comments.
   2. Next pages:
      a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
      b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
         1) In the order that the comments or questions were presented throughout the submittal.
         2) Referenced by index section and page number on which the comment appeared.
         3) Acceptable responses to Engineer's comments are either:
            a) Engineer's comment or change is accepted and appropriate changes are made.
            b) Explain why comment is not accepted or requested change is not made.
            c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
         4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
         5) No further review by the Engineer will be performed until a response for previous comments has been received.
   3. Remaining pages:
      a. Actual submittal data:
         1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
         2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

D. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Furnish submittals in the following general order, each in a separate bound set:
    a. Schedule of Values.
    b. Product Data.
    c. After approval of the Product Data, submit the Project Shop Drawing submittals.
    d. Loop Description Submittal.
    e. The Process Control and SCADA Software Submittal including, control system software, programming, and screens.
    f. Testing, Calibration and Start-up procedures.
    g. Operation and Maintenance Data.
    h. Training Submittals.
    i. Record Documents.
4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
    a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
5. Submit copies of shop drawings, and product data:
    a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
    a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
7. Exceptions to Specifications and Drawings:
    a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
    c. Acceptance of any exception is at the sole discretion of the Engineer.
        1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
    d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

E. Submittal preparation:

1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
    a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
    b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

F. Specific submittal requirements:
1. Shop drawings:
    a. Required for materials and equipment listed in this and other sections.
    b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
    c. Shop drawings requirements:
        1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
        2) Locations of conduit entrances and access plates.
        3) Component layout and identification.
        4) Schematic and wiring diagrams with wire numbers and terminal identification.
        5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
        6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
        7) Weight.
        8) Finish.
        9) Nameplates:
            a) As specified in Section 16075.
        10) Temperature limitations, as applicable.
    d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
    e. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
        1) Uniquely number each wire per the Specifications.
    f. Wire numbers must appear on all equipment drawings.
    g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
        1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.

2) Binder ring size: 2 inches.

h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
   1) The firm's registered business name.
   2) Firm's physical address, email address, and phone number.
   3) Owner’s name.
   4) Project name and location.
   5) Drawing name.
   6) Revision level.
   7) Personnel responsible for the content of the drawing.
   8) Date.

i. The work includes modifications to existing circuits:
   1) Clearly show all modifications to existing circuits.
   2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
   a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
   b. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
      6) Identify model number and options for the actual equipment being furnished.
      7) Neatly cross out options that do not apply or equipment not intended to be supplied.
   c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
   d. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
      1) Uniquely number each wire per the Specifications.
   e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Completed Motor Data Sheet, as specified in Section 16222, for every motor furnished:
   a. Submit one copy of the Motor Data Sheet to the Engineer for review as part of the associated equipment submittal.
5. Operation and maintenance manuals:
   a. As specified in Section 01782.
   b. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before energization start-up and/or commissioning.
   c. Submit preliminary sets of these manuals to the Engineer for review of format and content:
      1) Engineer will return 1 set with comments.

2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Pre-commissioning of the systems.

d. Incorporate changes that occur during startup and submit as part of the final manuals.
e. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
f. Include Record Documents and the approved shop drawing submittals, modified for conditions encountered in the field during the work.
g. Include signed results from Calibration, Loop Validation Tests, Pre-commissioning, and Performance Testing.
h. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
i. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
j. Operational Manual:
    1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
k. Spare parts list:
    1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
        a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
    2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
    3) Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
l. Control and SCADA System Software Record Documents:
    1) Include complete documentation of all the software programs provided for the entire control and SCADA systems, including:
        a) Listings of all application software on both hard copy and CD-ROM.
        b) Database, both hard copy and CD-ROM.
        c) Communication protocols.
        d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
m. Organize the operation and maintenance manuals for each process in the following manner:
    1) Section A - Process and Instrumentation Diagrams.
    2) Section B - Control Descriptions.
    3) Section C - Loop Drawings.
    4) Section D - Instrument Summary.
    5) Section E - Instrument Data Sheets and Brochures.
    6) Section F - Sizing Calculations.
    7) Section G - Instrumentation Installation Details.
    8) Section H - Test Results.
    9) Section I - Operational Manual.

10) Section J - Spare Parts List.
11) Section K - Control and SCADA System Software.

n. Additional operation and maintenance manual requirements:
1) Completely index manuals with a tab for each section:
a) Each section containing applicable data for each piece of equipment, system, or topic covered.
b) Assemble manuals using the approved shop drawings, and include, the following types of data:
(1) Complete set of 11-inch by 17-inch drawings of equipment.
(2) Complete set of 11-inch by 17-inch drawings of the control system.
(3) Complete set of control schematics.
(4) Complete parts list for all equipment being provided.
(5) Catalog data for all products or equipment furnished.

6. Material and equipment schedules:
a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

7. Itemized instrument summary:
a. Submit a hard copy of the instrument summary.
b. List all of the key attributes of each instrument including:
1) Tag number.
2) Manufacturer.
3) Model number.
4) Service.
5) Area location.
6) Calibrated range.
7) Loop drawing number.
c. Associated LCP, VCP, PCM, or PLC.

8. Instrument data sheets and cut sheets:
a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hardcopy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
1) Component functional description specified in this Section and indicated on the Drawings.
2) Manufacturers model number or other product designation.
3) Tag number specified in this Section and indicated on the Drawings.
4) System or loop of which the component is a part.
5) Location or assembly at which the component is to be installed.
6) Input and output characteristics.
7) Scale range with units and multiplier.
8) Requirements for electric supply.
9) Requirements for air supply.
10) Power consumption.
11) Response timing.

12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.

b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
2) Include a list of tag numbers for which it applies with each brochure or bulletin.
3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
4) Cross out models, features, options, or accessories that are not being provided.
5) Clearly mark and identify special options and features.

c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

9. Control panel hardware submittal:
a. Submit the following in 1 submittal package.
b. Complete and detailed bills of materials:
1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
2) Include all items within an enclosure.

c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and SCADA equipment.
d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
1) The manufacturer's model number or other identifying product designation.
2) Tag and loop number.
3) System to which it belongs.
4) Site to which it applies.
5) Input and output characteristics.
6) Requirements for electric power.
7) Device ambient operating requirements.
8) Materials of construction.

10. Schedule of values:
a. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit instrument and labor costs used in developing the final bid for the PCIS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer's

satisfaction that said per unit costs were used in the development of the final Bid amount.

11. Installation recommendations:
    a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
12. Training submittals:
    a. Develop and submit for review a general training plan. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
    b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
    c. Training course plan submittals:
        1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson.
        2) Describe any student pre-requisites for the course or training activity.
        3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
        4) Submit training materials.
    d. Incorporate all submittal review comments into the course.
    e. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
13. Record documents:
    a. Furnish as specified in Section 01770.
    b. Provide record documents of all Instrumentation Drawings.
    c. Record Drawing requirements:
        1) Update Record Drawings weekly.
        2) Record Drawings must be fully updated as a condition of the monthly progress payments.
        3) Submit Record Drawings upon completion of the Work for final review.
        4) Clearly and neatly show all changes including the following:
            a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
    d. Shop drawings:
        1) General:
            a) Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:
                (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
            b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters,

variable speed drives, control valves, flow meters, chemical feeders and other equipment related to the PCIS.

c) Generate all drawings developed for this project utilizing AutoCAD by Auto Desk Version 2004 or later:
   (1) Furnish on CD-ROM disks containing the following for each drawing:
      (a) Original CAD files
      (b) PDF version.
   (2) Provide hard copies on 11 inch by 17 inch plain bond paper.

d) Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
   (1) Should an error be found in a shop drawing during installation or startup of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
   (2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
   (3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using plain Bond paper.
   (4) Provide electronic copies of these documents on CD-ROM disks in AutoCAD DWG format and Adobe PDF format.. Size all drawings to be readable and legible on 11-inch by 17-inch media.

e) Submittal Documents:
   (1) Provide an interim submittal of Record Documents after the PCIS system Pre-commissioning but prior to testing.
   (2) Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01782 or the General Requirements.

f) Review and Corrections:
   (1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   (2) Promptly correct and re-submit Record Documents returned for correction.

2) Furnish written information prepared specifically for this Project using Microsoft Word.doc and Adobe .pdf formats and printed on 8.5-inch by 11-inch plain bond paper:
   a) Provide electronic copies of these documents on CD-ROM disks.

e. Review and corrections:
   1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   2) Promptly correct and re-submit record documents returned for correction.

14. Loop Drawings:
   a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:

1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.

b. Show every instrument and I/O point on at least one loop diagram.
c. Provide a complete index in the front of each bound volume:
1) Index the loop drawings by systems or process areas.
d. Provide drawings showing definitive diagrams for every instrumentation loop system:
1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
2) Furnish a separate drawing sheet for each system or loop diagram.
e. In addition to the ISA-5.4 requirements, show the following details:
1) Functional name of each loop.
2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
3) Show all terminal numbers, regardless of the entity providing the equipment.
4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCIS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.

15. Instrument Installation Drawings:
a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
d. For each detail, provide, as a minimum, the following contents:
1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
2) Ambient temperature and humidity where the instrument is to be installed.

3) Corrosive qualities of the environment where the instrument is to be installed.
4) Hazardous rating of the environment where the instrument is to be installed.
5) Process line pipe or tank size, service and material.
6) Process tap elevation and location
7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
8) Routing of tubing and identification of supports.
9) Mounting brackets, stands, anchoring devices, and sun shades.
10) Conduit entry size, number, location, and delineation between power and signal.
11) NEMA ratings of enclosures and all components.
12) Clearances required for instrument servicing.
13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

16. Control Panel Drawings:
    a. Layout Drawings:
        1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
        2) As a minimum, include the following information:
            a) To scale front, side, and plan views.
            b) Dimensions.
            c) Interior and exterior arrangements.
            d) Mounting information, including conduit entrance location.
            e) Finish data.
            f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
            g) Nameplate legend including text, letter size, and colors.
    b. Wiring and Piping Diagrams:
        1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
        2) Include the following information:
            a) Name of panel.
            b) Wiring and piping sizes and types.
            c) Terminal strip numbers.
            d) Wire tags and labels.
            e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
            f) Electrical control schematics in accordance with ANSI standards.
    c. Installation drawings:
        1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
        2) Provide scaled drawings and show the position of the equipment at its intended installation location.
        3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.

4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

17. Schematic Diagrams:
    a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
    b. Include device and field connection terminal numbers on all schematic diagrams.
    c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.
18. Control System Diagram:
    a. Submit a complete set of control system diagrams including the following information:
        1) All PLCs, workstations, printers, communication devices, and communication links:
            a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
        2) All cables required for communication requirements.
        3) Show each component fully annotated with conduit size and number associated with the power source.
19. Process Control & SCADA Software Submittal:
    a. In accordance with Product Data and Shop Drawing general requirements.
    b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
        1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
    c. A complete listing of the PCIS system point I/O database:
        1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
        2) Organize on a site-by-site basis, separate by point type.
        3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
    d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
    e. Preliminary overview, screens, station graphic displays, and preliminary reports.
    f. Refer to Section 17762 for additional requirements.
20. Instrumentation and Control System Contractor Statement of Qualifications:
    a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
21. Control Descriptions:
    a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
        1) Include all functions depicted or described in the Contract Documents.
        2) Include within the Control Description content:

a) All specific requirements.
b) All common requirements that pertain in general to all loops.
c) Listing all ranges, setpoints, timers, values, counter values, etc.

22. "The Contractor is required to inform the Owner and Engineer of the day, date and time for a scheduled test at least 15 calendar days before the test takes place to allow the Owner and Engineer sufficient time to plan travel to the test site."
23. Testing, Calibration, and Start-up Submittal:
    a. General testing submittal requirements are specified in this Section. Additional requirements are specified in Section 17950 and other Sections.
    b. Test Procedure Submittals:
        1) Submit the proposed procedures to be followed during tests of the PCIS and its components in two parts:
            a) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
            b) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
    c. Provide certified and witnessed test and calibration checklists for each of the following tests:
        1) Calibration, adjustment, and test details for all components and systems.
        2) Factory Acceptance Tests.
        3) Loop Validation Tests:
            a) Loop Validation Certifications:
                (1) After the field device loop tests have been successfully completed for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, ICSC and the Owner's Representative, with test data entered, together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.
        4) Pre-commissioning Test.
        5) Performance Test.
    d. Factory Acceptance Test:
        1) Include complete test procedures and forms to be used during the test.
24. Test reports:
    a. As specified in Section 01330.
    b. Include the following:
        1) A description of the test.
        2) List of equipment used.
        3) Name of the person conducting the test.
        4) Date and time the test was conducted.
        5) All raw data collected.
        6) Calculated results.
        7) Each report signed by the person responsible for the test.

c. Additional requirements for acceptance test reports are specified in Section 17950.

25. Factory acceptance test:
    a. As specified in Section 01330.
    b. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. ICSC qualifications:
1. General information on the proposing company:
    a. Document that the ICSC company has been actively involved in the instrumentation, PLC based control systems, and SCADA systems business for a minimum of five years and has adequate facilities, organization structure, manpower and technical and managerial expertise to properly perform the Work as specified in these Specifications.
    b. Submit a financial prospectus indicative of the corporation's financial state. This prospectus shall also include:
        1) A letter from a financial institution indicating a current line of credit and bonding limit which can be applied to this Project.
        2) Latest annual report or reviewed financial statement.
2. Document that the ICSC has a qualified permanent service facility:
    a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and start-up all of the instrumentation, control, telemetry, and SCADA systems hardware and software furnished under this Contract, including remote diagnostic capability.
    b. Document in-house resource of permanent personnel experienced in the design and programming of equipment and systems as specified in these Specifications.
    c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.
    d. Document that the firm is a recognized or certified “system integrator partner” or similar designation for the SCADA software and PLC system being supplied for this Project.
3. Similar project experience of the company:
    a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring and panel assembly drawings), software configuration and documentation, field testing, calibration and start-up, operator instruction and maintenance training. In addition, provide the following information for each project:
        1) Name of plant or system owner, contact name, and current telephone number. Design engineer’s name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for prequalification.

2) Manufacturer and model number(s) of the PLC based control system and the computer-based SCADA system used for both hardware and software.
3) Brief description of the system.
4) Approximate number of input and output signals: analog, digital, and fieldbus.
5) Brief application software description.
6) Contracted cost of the system, separate by base amount and any change orders for the completed projects.
7) Duration of the project and date of completion.

4. Information on the proposed Project team members:
   a. Provide the name and resume of the individual persons who will be responsible for each of the following:
      1) Office engineering and management of this Project.
      2) Lead for software configuration/programming.
      3) Individual who will be responsible for the hardware and hardware interface design.
      4) Individual who will be responsible for field testing, calibration, start-up.
      5) Individual who will be responsible for operator training.
   b. All of these individuals must be permanent employees of the proposing firm.
5. Determination of the proposed ICSC qualifications is at the sole discretion of the Engineer.

C. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

D. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.

E. ICSC:
1. The Contractor, through the use of a pre-qualified qualified ICSC, is responsible for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.
2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, [program], test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and SCADA system including application software, for a complete, integrated and functional PCIS system**.**
3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

F. System supplier responsibilities:
1. In accordance with the requirements of the Electrical Specifications.
2. System supplier:
   a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and the Instrumentation and Control

Specifications, and all Work indicated on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.

3. Contractual relationship:
   a. Form a contractual relationship between the electrical subcontractor and the ICSC.
   b. Requirements for the first tier subcontractor:
      1) Contract directly with the Contractor.
      2) Be either the electrical subcontractor or the ICSC.
   c. Requirements for the second tier subcontractor:
      1) A division of the first tier subcontractor, or
      2) A joint venture with the first tier subcontractor, or
      3) A subcontractor to the first tier subcontractor.
   d. The system supplier manages, directs, and supervises all of the Work of its second tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system including, but not limited to, all Electrical, Instrumentation, and Process Contract Drawings, the Instrumentation and Control and the Electrical Specifications:
      1) Provide any additional conduit, wire, etc.
      2) Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.
      3) Ensure compatibility between the PCIS system and the electrical system being installed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store all equipment and materials delivered to the job site in a location that will not interfere with the construction or the Owner's operations.

B. Shipping precautions:
   1. After completion of shop assembly, successful FAT, pack all equipment, cabinets, panels, and consoles in protective crates and enclose in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
   2. Place dehumidifiers when required, inside the polyethylene coverings.
   3. Skid-mount the equipment for final transport.
   4. Provide lifting rings for moving without removing protective covering.
   5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

C. Special instructions:
   1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
   2. The Contractor shall ship the PCIS equipment listed below to Programmer's office, within 175 days after Notice to Proceed is issued to the Contractor:
      a. PLCs to be programmed by Programmer, including all chassis, power supplies, CPUs, IO modules, cables, programming software, and related equipment.

b. All network communications equipment and cables less than 10 feet in length.
c. Any personal computers and related software.

3. The Programmer shall be allowed to keep the above equipment for a minimum of 180 calendar days and additionally until 30 days prior to the start of the factory test for the applicable PLC control panels. The Contractor shall allow sufficient time in the Project Schedule for this 180-day requirement. The Contractor is responsible to obtain necessary submittal reviews, order equipment, and allow sufficient delivery time to comply with this requirement. No schedule extension shall be allowed due to failure of the Contractor to comply with these requirements.
4. The Contractor shall also supply, for the use of the Programmer, samples of any devices or equipment that will communicate to the Programmer-programmed PLCs using Modbus, Modbus plus, Fieldbus, or any other digital network. These samples must be shipped to the Programmer's facility and remain there for a minimum of 90 days prior to the PLC panel factory tests.
5. The Contractor shall be responsible for shipping the above equipment from the Programmer's facility. At the designated time for shipment of the above equipment to the factory test site or the field (whichever applies), the Contractor shall send personnel to the Programmer's office to package and ship the equipment to the factory test site. The Contractor shall have sole responsibility to package and ship the equipment, including packing materials and shipping charges. Prior to packaging and shipping, the Contractor shall examine and test all equipment, as needed, and shall certify, in writing, that the equipment appears to be in proper working order, and shall deliver the certification to the Programmer, who will forward copies to the Owner and Engineer.

D. Tagging:
1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCIS.
3. Tag instruments immediately upon receipt in the field.
4. Prominently display identification on the outside of the package.
5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

E. Delivery and inspection:
1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
1. Provide a PCIS, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
2. Seismic classification:
a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612.

3. Wind:
    a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614.
4. Altitude, temperature and humidity:
    a. As specified in Section 01610.
    b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
    c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
        1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
5. Area classifications:
    a. Furnish enclosures that match the area classifications as specified in Section 16050.
6. Site security:
    a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329.

1.09 SEQUENCING

A. General:
    1. As specified in Section 01312.
    2. Testing requirements are specified in Section 17950 and other sections.
    3. Work restrictions and other scheduling requirements are specified in Section 01140.

B. Submit proposed ICSC statement of qualifications:
    1. The ICSC must be approved by the Engineer before any other Work commences.

C. Pre-submittal conferences:
    1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
    2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
        a. Vendor control panels.
        b. Chemical feed systems.
        c. Motor control centers.
        d. Switchgear.
        e. Variable frequency drives.
        f. Lighting.
        g. Engine generators.
    3. The Programmer shall be invited to attend the pre-submittal conference.

D. System configuration meetings:
   1. Review the system configuration, the system database, control schemes, displays, report formats, etc. with the Engineer and Owner on at least 3 occasions during development.
   2. Preliminary meeting: Before configuration work is begun. The ICSC must bring to this meeting example of displays, display symbols, reports, etc. to show the capabilities of the system software.
   3. Intermediate review meeting: Held after the initial database is entered and typical screens and reports have been entered.
   4. Final review meeting: Held after initial completion of all configuration work. This final meeting may not be held in conjunction with the FAT. Make final format revisions after this review.
   5. Additional requirements as specified in Sections 17100, 17761 and 17762.
   6. Attend meetings to coordinate the SCADA system configuration, the system database, control schemes, displays, etc., with the Programmer, Engineer and Owner on at least three occasions during development.
   7. Preliminary meeting: Meet before configuration work is begun on any PLCs programmed by the Contractor (including those provided through subcontractors and suppliers). Contractor shall provide a list of each PLC and other programmable devices that will interface to the rest of the SCADA system, including make, model, and a description of the interface; provide contact information for each individual responsible for programming each said PLC and device; and provide a listing of the submittals that will contain SCADA interface information with a schedule for when each submittal will be provided.
   8. Intermediate review meeting: Held after approximately one-half of the interface submittals identified in the Pre-submittal Conferences paragraph above have been submitted. Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting. Meet to discuss SCADA interface submittals and requirements.
   9. Final review meeting: Held after all SCADA interface submittals have been submitted. Meet to discuss SCADA interface submittals and requirements.
   10. Additional requirements as specified in Sections 17100, 17761, and 17762. Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting by telephone conference call.

E. FAT:
   1. Before the delivery and installation of control panels, PLCs, SCADA equipment, and other PCIS components at the job site, but after the procurement and assembly of components, perform FAT testing.
   2. Schedule the FAT after receiving approval of the FAT procedures submittal.
   3. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
   4. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.

F. Loop validation test.
   1. Notify the Engineer of scheduled tests a minimum of 30 days before the estimated completion date of installation and wiring of the PCIS.
   2. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.

3. Loop validation certifications:
    a. After the field device loop tests have been successfully completed as specified in Section 17950 for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, ICSC, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.

G. Training:
1. As specified in Section 01756.
2. Complete all training before the pre-commissioning phase of the project may start.
3. Schedule the training sessions a minimum of 15 days before the start date of the courses.
4. Submit training manuals to the Engineer a minimum of 10 days before starting the training session.
5. Within 10 days after the completion of each session, submit the following:
    a. A list of all Owner personnel that attended the session.
    b. A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.

H. Pre-commissioning test:
1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
2. Acceptance of the PCIS pre-commissioning testing must be provided in writing by the Engineer before the performance testing may begin.
3. The Programmer will assist with pre-commissioning testing for PLCs programmed by the Programmer, as specified in Section 17950.
4. The Programmer shall not be required to be on site, nor shall the Programmer be required to supply application software, until the loop validation tests are complete for a PLC and all prerequisites for the pre-commissioning test are completed.

I. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before performance testing commences, suitably wrapped and identified.

J. Performance testing:
1. Complete pre-commissioning test a minimum of 5 days before the performance test.
2. Conduct a 90-day performance test.

K. Substantial completion: The following conditions be fulfilled before the PCIS is considered complete:
1. All submittals have been completed and approved.
2. The PCIS has been calibrated, loop tested and pre-commissioned.
3. The Owner training has been performed.
4. All required spare parts, expendable supplies, and test equipment have been delivered to the Owner.

5. The performance test has been successfully completed.
6. All debris associated with installation of instrumentation has been removed.
7. All probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. Warrant the PCIS as specified in Document 00700:
   1. Provide additional warranty as specified in the individual Instrumentation and Control Specifications.

1.12 SYSTEM START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by the Contract Documents.

C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

D. Submit all special tools and spare parts, suitably wrapped and identified, before performance testing commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.

B. Allowable manufacturers are specified in individual instrument and equipment specifications in other sections of the Instrumentation and Control Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

C. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
      c. Analog signals within enclosures may be 1 to 5 VDC.
      d. Electrically or optically isolate all analog signals from other signals.
      e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
      g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. Pneumatic Signals:
      a. All pneumatic signals: 3 to 15 pounds per square inch gauge.
   3. Discrete input Signals:
      a. As indicated in the controller hardware specification.
   4. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
      c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.

D. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
   1. Provide control panels with a signal ground bus, isolated from the power ground bus:
      a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
   2. Ground single point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
   3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
   1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
      a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
      b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
      c. Filter all air to 5 micron maximum particle size.
      d. Provide low pressure switch to alarm on insufficient air supply.

2.07 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.

B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
   1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

C. Factory testing is specified in Section 17950 and other sections of the Electrical, and the Instrumentation and Control Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. The ICSC is encouraged to visit the site and attend a pre-bid conference and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

C. Provide a complete instrumentation and control system:
   1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions as indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer’s instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.

b. Provide sun shields for all field electronic instruments exposed to direct sunlight.

3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
   a. Type of flexible conduit required for the area classification:
      1) Area classification as specified in Section 16050.
   b. Maximum length of 18 inches.
4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
   a. Special cable applications shall be in accordance with the NEC.
5. Verify the correctness of each installation:
   a. Polarity of electric power and signal connections.
   b. Ensure all process connections are free of leaks.

E. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16th inch per foot to allow for draining of any condensate.
4. Bends:
   a. Use proper tool.
   b. Make bends for parallel lines symmetrical.
   c. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean all ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
   a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Conduit, cables, and field wiring:
1. Provide all PCIS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
2. Provide terminations and wire identification as specified in the Electrical Specifications.
3. Protect all wiring from sharp edges and corners.
4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.

G. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

H. Instrument tagging:
1. As specified in Section 16075.

2. Provide all field-mounted instruments with nameplates:
    a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
        1) Affix tags with stainless steel wire fasteners.
3. Provide all back of panel instruments with nameplates:
    a. Engraved with the instrument's full tag number as indicated on the Drawings:
4. Provide all front of panel instruments with a nameplate:
5. Provide all front of panel instruments with a nameplate:
    a. Engraving to include the following:
        1) Instrument's full tag number
        2) Service description.
    b. Nameplates:
        1) Secure nameplates to the panel with stainless steel screws.
        2) Use an approved adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
1. Terminate all cables and conductors on terminal blocks.
2. Terminal block enclosures:
    a. Suitable for the area classification as specified in Section 16050.

J. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4 wire transmitters and analyzers:
    a. Protect both power source and signal loop.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Inspection:
1. Allow for inspection of PCIS installation as specified in Section 01450.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect cable terminations.
    g. Inspect/witness instrument calibrations/verifications.

4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950.

B. Instrument Installation Inspection:
   1. Provide any assistance necessary to support inspection activities.
   2. Inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions etc., that could effect the instruments accuracy or repeatability.
      c. Inspect installation for compliance with Drawings and Specifications.
      d. Inspect installation for obstructions and adequate clearances around equipment.
      e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      f. Inspect equipment nameplate data to verify compliance with design requirements.
      g. Inspect cable terminations.
      h. Inspect/witness instrument calibrations/verifications.
   3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950.

C. Field testing is specified in Section 17950. Additional general requirements are specified in Section 01756.

D. Installation supervision:
   1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
      a. Installation resources:
         1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
      b. Provide technical assistance to installation personnel by telephone:
         1) Furnish installation personnel with at least one copy of the approved submittals, including all installation details.
      c. Periodic inspections during the construction period.
      d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
      e. Field verify accuracy and calibration of all instruments.

3.08 ADJUSTING

A. Control valves:
   1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
   2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make all revisions necessary to the control system software, as directed by the Engineer. It is understood that the Contractor knows and agrees that changes will

be required in the control system software during the factory acceptance tests, the pre-commissioning, performance testing, start-up and during the warranty period.

3.09 CLEANING

A. As specified in Section 01770.

B. Vacuum clean all control panels and enclosures before start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label all spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

G. As specified in other sections of the Contract Documents.

3.10 DEMONSTRATION AND TRAINING

A. Demonstration requirements are specified in Section 17950.

B. Training:
   1. General:
      a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.
      b. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
         1) All training described below shall be provided by the Contractor.
         2) The Programmer is not responsible for the training described in this Section.
         3) The Programmer will provide training on software provided by the Programmer.
      c. Conduct all training at the Project Site unless another location is approved by the Engineer and Owner:
         1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.
      d. Tailor training classes to the specific needs of the class participants:
         1) Develop separate courses for operators, maintenance staff, and supervisors:
            a) The specific categories and number of personnel in each category are identified below.
         2) Furnish training courses that are a combination of classroom and hands-on training:
            a) To the greatest extent possible, utilize components from the Owner's PCIS system.

b) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.

3) Present the minimum number of sessions, specified in Table 17050-3.10-T1, for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.

4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.

e. Schedule individual training classes with the Owner at least 3 weeks before the start of the class:

1) Schedule all training classes Monday - Friday between 7:30 AM and 3:30 PM.

2) Each individual daily training session, travel time excluded:

a) Minimum duration of 4 hours.

b) Maximum duration of 7 hours.

c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.

3) Complete training for maintenance personnel 90 days before performance testing.

4) Complete operator training classes before start-up of the SCADA system, or any part of it:

a) As specified in the Sequencing article of this Section.

5) Schedule follow-up training classes after SCADA start-up on a schedule determined by the Owner.

f. Furnish highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:

1) Instructors are subject to the approval of the Engineer.

2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the SCADA system implementation team.

3) One of the individuals conducting the SCADA system training course must be the same individual responsible for the majority of the programming that was performed for the instrumentation and control system.

2. Training manuals and materials:

a. Furnish training manuals and other materials for training courses.

b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.

c. The manuals are to serve as teaching aids during presentation of the training classes.

d. Manuals are to serve as reference material after the training has been completed.

Table 17050-3.10-T1

Course Title	Minimum Course Length (days per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	1	5	1
Operator Training - Basic	1	5	1
Historian Data and Report Training	1	3	1

Table 17050-3.10-T1			
Course Title	**Minimum Course Length (days per session)**	**Personnel (Estimated Number of Students)**	**Minimum Number of Sessions**
PLC Hardware	1	3	1
PLC Software	1	3	1
HMI Hardware and Software	1	3	1
Radio and Network Equipment	1	3	1
Instrument Training	1	3	1
Analytical Instrument Training	1	3	1

3. Training course requirements:
   a. System overview training:
      1) Furnish a training course that gives the Owner's supervisory level personnel an overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
   b. Operator training:
      1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
      2) Operator's training shall include the following for each vendor package and programmable device:
         a) Control system overview: Architecture, equipment functions, software components, etc.
         b) Display navigation, overview, and types of displays.
         c) Process and equipment monitoring and control: Basic principles and operation.
         d) Logging ON and OFF the system and description of the security and access system.
         e) Alarm subsystem.
         f) Trending: Provide a thorough session on how to use all trending functions.
         g) Reports: How to access, print, and review content.
         h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
         i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
   c. Historian system training:
      1) Furnish the following training:
         a) Introduction to relational databases.
         b) Introductory training on the specific relational database program used for the historian server.
         c) How to set up points for historian logging.

d) How to develop, edit, and print custom reports, in detail.
e) Introduction to use of the query language.
f) System maintenance.
g) Interface to networks outside of the SCADA system**.**

d. PLC hardware training:
1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, HMI hardware, control circuits, and analog circuits.
2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
3) PLC training may be provided by manufacturer's certified trainers.

e. PLC software training:
1) Furnish training on PLC software.
2) Two types of training are required, basic and project-specific:
a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer's certified trainers.
b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified member of the ICSC who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.

f. HMI hardware and software training:
1) Provide the following:
a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
b) Configuration of tag database.
c) Creating, editing, and saving display screens.
d) Troubleshooting.

g. Network equipment training:
1) Furnish basic training on all network hardware, switch and router configuration and software, and network monitoring software.
2) Include a detailed description and explanation of the installed network architecture, media, and functions.
3) Furnish an overview of the function and operation of each piece of network equipment.
4) Furnish training on network maintenance troubleshooting and repair.
5) Furnish training on how to install spare or off-line backup equipment.

h. Follow-up training:
1) Provide a series of on-site follow-up training classes beginning after start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.

2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
   a) Schedule at the Owner's discretion on non-consecutive days spaced out over the start-up and warranty period.

i. Instrumentation training:
   1) Furnish training covering all instruments and control panels.
   2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as specified in this Section and specifically determined in the approved training plan.
   3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
   4) Furnish training on the operation of new hardwired controls.

j. Analytical instrument training:
   1) Furnish training covering all analytical instruments.
   2) Furnish the specified quantity of training, allocated to cover new analytical instruments as specified in this Section and specifically determined in the approved training plan.
   3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the analytical instruments furnished within this Project.
   4) Provide training by manufacturer.

4. Recording training sessions:
   a. Record all training.
   b. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
   c. Provide all the necessary cameras and recording equipment.

3.11 PROTECTION

A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17100

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Contractor-developed loop description submittal requirements.
   2. General programming requirements.
   3. Common control functions:
      a. General control and monitoring functions to be provided throughout the PCIS system.
         1) These requirements apply to all systems, and supplement the specific loop descriptions in Section 17101 and information indicated on the Drawings.

A. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      b. Section 17101 - Specific Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.

C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.

D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.

E. Slew rate: Rate of change in respect to time.

F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.

G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. As specified in Section 17050.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)`

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. As specified in Section 17050.

B. General programming requirements:
   1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
      a. Unless otherwise noted, utilize floating-point format for all PLC algorithms and calculations.
      b. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
   2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the HMI or OIT. Update and display the current value at all locations, regardless of where the last change was made.
   3. Program slew rates for all setpoints to limit the effect of updated setpoints on the process:
      a. Provide for control setpoints and manual speed and position selections.
      b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
      c. Provide operator access to change slew rates from the OIT.
   4. Saved setpoints:
      a. Provide an operator selection to save all setpoint values.
      b. Furnish 1 or more screens at the OIT that display the initial values for all setpoints defined during start-up and the value for each setpoint the last time they were saved.
      c. Provide an operator selection to restore all setpoints to the initial start-up value.
      d. Provide an operator selection to restore all setpoints to the last saved value.
   5. Store a copy of all adjustable parameters and accumulated and integrated totals in SCADA:
      a. Upon re-loading of the PLC program, re-load these values to the PLC from SCADA.
   6. Calculated values:
      a. Program calculations such that division by zero errors cannot occur.
      b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.

c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years.

7. Timers:
   a. Provide programmable settling and proving timers in all control sequences for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
      1) The settling timers may be overridden by setting the timer to 0 seconds.
   b. Embed the timers in the PLC logic, tune in the field, and list separately as part of the software submittal and O&M manual.
8. PCM status:
   a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described herein completely independent from the functions of the SCADA system PC-based operator interfaces:
      1) Failure of the SCADA system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
   b. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs or I/O in the control system, including but not limited to the following:
      1) PLC cabinet over-temperatures from high temperature switch.
      2) Intrusion status on all enclosures equipped with intrusion switches.
      3) AC power failure:
         a) Monitor ahead of UPS.
      4) DC power supply failure:
         a) For redundant power supplies, alarm when either power supply fails.
      5) UPS failure signal.
      6) Voltage levels, charging status, battery condition and alarm information for solar-powered panels.
9. PLC system communication status:
   a. Furnish a minimum of 1 screen to display all communication errors and status within the PCIS:
      1) Communication between SCADA and PLCs, PLC to PLC, PLC to RIO.
      2) Display status of each node, and summary of failures over the past 60 minutes.
   b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
   c. In the event of communications loss:
      1) Continue normal operation at each PLC.
      2) Where control parameters are received over a communications link:
         a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:

(1) Ensure that the operator can control the process using PCIS HAND mode at the local HMI.

b) If a link fails where process elements use the remote value to determine setpoints, settings or control levels, continue to operate using the last value received:
   (1) Provide a manual over-ride entry at the local HMI to allow an operator to enter a different value for any such remote signal.
   (2) Generate an alarm whenever an over-ride value is in use.

C. Common control functions:
   1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
   2. Alarms:
      a. Generate alarms within the PLC logic.
      b. Indicate alarms at the HMI and OIT. Enable acknowledgement from either the OIT or the HMI.
      c. Generate high, high-high, low, and low-low level alarms where indicated:
         1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
         2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
      d. Flash all alarm and fail conditions and their respective indicators on the PCIS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
      e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
         1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
      f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
      g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
         1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
         2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
      h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
      i. Furnish an alarm silence pushbutton at each PCM, HMI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
      j. Any alarm that is not acknowledged after a setpoint period of time shall activate the auto dialer.
      k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
         1) The lamp test may sequence through blocks of lights.
         2) Minimum on time for each lamp during lamp test 15 seconds.

3. Where a reset is shown for counts, totals and times maintained in the PLC:
    a. Provide a reset selection on the OIT screen that displays the value.
    b. Provide a preset function on the OIT to allow a operator-entered value to become the current accumulated total.
    c. Limit access to the reset and preset functions to operators with suitable security level.
    d. Log the value before reset, operator, time, and date of reset in the SCADA archive.
    e. Log the value before preset, preset value, operator, time, and date of preset in the SCADA archive.
4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
    a. Display total starts on PCIS screens, and provide a reset function.
    b. Where indicated, calculate number of starts for each day:
        1) Display current day and previous day starts on PCIS displays.
        2) Do not reset daily start count when overall count is reset.
        3) Archive starts for each day through SCADA.
5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
    a. Display total run time in hours on PCIS screens.
    b. Where indicated, calculate total run time for each day:
        1) Display current day and previous day run time on the OIT to the nearest 0.1 hour.
        2) Do not reset daily run time when overall time is reset.
        3) Archive run time for each day through SCADA.
6. For all monitored analog values:
    a. Convert all values to engineering units in floating-point format within the PLC.
    b. Maintain trends in SCADA.
    c. Totalize flows in the PLC logic:
        1) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
        2) Where no totalizer input is shown, integrate the analog input over time.
        3) Display totals on the OIT and HMI.
        4) Archive totals to the historical database through SCADA.
    d. Calculate hourly, daily, and monthly averages:
        1) Calculations may be performed by the PLC or SCADA.
        2) Display averages on the OIT, and archive through SCADA.
    e. Calculate minimum and maximum values for each hour, day, and month:
        1) Calculations may be performed by the PLC or SCADA.
        2) Display minima and maxima on the OIT, and archive through SCADA.
    f. Generate an alarm whenever an over-ride value is in use.
7. Analog data processing:
    a. Engineering units conversion:
        1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
    b. Analog magnitude checking:

1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.

c. Analog value quality:
   1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO, and generate alarms for the following conditions:
      a) Rate of change in excess of acceptable limit:
         (1) Provide a separate rate limit for each value.
      b) Stale value:
         (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to have some variation each time the input is read, alarm when there is no change in the value for 10 times the normal expected scan or communication update.

8. Analog device override (HMI and OIT):
   a. Provide the following functions from the OIT and the local HMI for each and every analog input:
      1) An over-ride value to be used in place of the analog input:
         a) Enter in engineering units:
            (1) Display the calibrated range in engineering units.
            (2) Only allow entries within the calibrated range of the instrument.
         b) When the analog input is enabled, track the analog input so that the over-ride matches the analog input value when the input is initially disabled.
         c) Maintain over-ride status and value in the PLC.
         d) Only allow access to over-ride selections and settings to operators with sufficient security.
      2) An enable/disable selection:
         a) When enabled, the value used by the PCIS system is equal to the analog input value.
         b) When disabled, the analog input is ignored, and the over-ride value is used for all control and display functions.
         c) Generate an alarm whenever an analog input is disabled.
         d) Enter a value for the analog input from the PCIS system to the PLC.
      3) Use the over-ride value for all display and control functions instead of the actual analog input value.
   b. Provide the following functions in the PLC, with selections and value entry from the OIT and/or HMI:
      1) An over-ride value to be used in place of the normal output value:
         a) Enter in percent of output span.
         b) When the analog output is enabled, track the analog input so that the over-ride matches the analog output value when the output is initially disabled.
      2) An enable/disable selection:
         a) When enabled, the value sent to the output is the value determined by the PLC based on the control logic or operator-entered value in PCIS HAND.
         b) When disabled, the calculated PCIS HAND values are ignored, and the over-ride value is sent to the output.
         c) Generate an alarm whenever an analog output is disabled.

9. Tank and vessel levels:
    a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
        1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
    b. Monitor rate of change of volume on all tanks and vessels:
        1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
        2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.
10. I/O filtering and processing:
    a. Analog input filtering:
        1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
        2) Monitor analog input signal quality:
            a) Over range: The input value is above the normal range (typically over 21 mA).
            b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
            c) Generate alarms for over or under range inputs.
            d) Do not use over or under range values for control or calculation purposes:
                (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
                (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
        3) Digital input filtering (proving timer):
            a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
            b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
11. Instrument scaling (OIT/HMI):
    a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
        1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
        2) For discrete instruments, display calibrated pick-up and drop-out values.
12. PCIS HAND-OFF-AUTO:
    a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCIS, accessed from an HMI or OIT for operators with sufficient security, to provide the following operating modes:

1) PCIS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
2) PCIS HAND: Enables PCIS Manual control where control decisions are made by an operator through the PCIS START-STOP, OPEN/CLOSE, or other selections as indicated.
3) PCIS OFF: Automated PCIS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.

13. Display the current status of all operator selections (PCIS HAND/AUTO, PCIS START/STOP, etc.) on HMI and OIT.
14. Permissive:
    a. Implement software permissive where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software permissive when equipment is operating in PCIS AUTO or PCIS HAND:
    b. Use hard-wired permissive for equipment protection where indicated.
15. Process control algorithms:
    a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
        1) When the error between process variable and setpoint is beyond a setpoint deadband:
            a) Jog valve or ramp speed in the required direction for a preset “Jog Time” or until the process variable reaches or passes the setpoint.
            b) Then hold speed or position through a setpoint “Hold Time.”
            c) Continue alternating jog and hold until the error is less than the deadband.
        2) Provide operator access to Jog Time and Hold Time setpoints from the OIT.
    b. PID algorithms: Use where indicated, or where necessary to provide fast response:
        1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
            a) Display Output, CV.
            b) Display Setpoint, SP.
            c) Display Process Variable, PV.
            d) Allow for operator selection of Automatic or Manual control of the output.
            e) Under Manual control of output allow the operator to enter the desired output value.
            f) Allow for input of the 3 Proportional, Integral and Derivative tuning parameters.

g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCIS), or when the equipment has reached a physical limit.
h) When controlled equipment is being operated in remote PCIS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.

16. Equipment alternating and sequencing:
    a. Distribute number of starts and run time equally between identical equipment.
17. Motor control:
    a. Monitor the device's HAND-OFF-AUTO (HOA) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
        1) Display current AUTO status on the PCIS screens.
    b. Monitor the device's running status from the starter auxiliary or run status input:
        1) Display the current status (running or stopped) on the PCIS screens.
        2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
        3) Provide time stamp for each start.
        4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
    c. When equipment control has been given to the PLC as reported by the HAND-OFF-AUTO switch, allow selection of PCIS AUTO or PCIS HAND control modes based upon operator selection using the PCIS screens.
    d. Starting, stopping and running when the device HOA is in HAND:
        1) With the HOA switch in the HAND position, the motor is controlled by the START and STOP pushbuttons.
        2) With the HOA switch in the OFF position, the motor is prohibited from running.
        3) With the HOA switch in the AUTO position, the motor is controlled remotely.
    e. Starting, stopping and running when the device HOA is in AUTO:
        1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), HOA is in AUTO, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
            a) Provide "Control Activation" timers for each piece of controlled equipment:
                (1) If the HOA and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
                    (a) De-activate the output.
                    (b) Place the device in a "Failed" state.
                    (c) Generate a "Failed to Respond" alarm.

2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), HOA is in AUTO, and the device is reported to be running, start the “Control Activation” timer:
    a) If the HOA and required stopped status do not change, and the PLC does not lose the running status within the “Control Activation” time period:
        (1) Keep the RUN output off or the STOP output on.
        (2) Place the device in a “Failed” state.
        (3) Generate a “Failed to Respond” alarm.
3) Re-establish PLC control of a device in a “Failed” state only after the following:
    a) An operator turns the device’s HOA switch out of AUTO, and back to AUTO (i.e., AUTO input to the PLC cycles off and back on).
    b) An operator acknowledges the fault from SCADA.

f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.

g. Control two-speed motors similar to other motors, except as listed below:
1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
2) Start all two-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a “Fast to Slow” time delay before energizing the RUN-SLOW or START-SLOW output.

h. Simultaneous starts:
1) Prevent more than one motor-driven load 25 HP or larger in the same facility from starting concurrently:
    a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).
2) Use the same logic to prevent multiple large devices from starting concurrently on restoration of power after a power outage, whether operating on generator or utility power.

i. Speed control:
1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
2) Operate speed control within a pre-defined range:
    a) Minimum speed as determined by equipment manufacturer. The higher of:
        (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
        (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
    b) Maximum speed 100 percent (60 hertz) or as identified by equipment manufacturer.

3) Where multiple equipment may operate together to maintain the same process condition:
    a) Provide an operator selection for starting sequence.
    b) Start the first equipment at a preset starting speed.
    c) When one or more equipment is running and the speed control algorithm reaches a preset “Start Next” speed value (initially 95 percent of speed range) through a preset time delay:
        (1) Start the next available equipment at the preset starting speed.
        (2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if one pump is running and the second pump will be added, then the total flow of both pumps running at mid operating speed should be approximately the same as flow of one pump at Start Next speed).
        (3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.
        (4) Operate all equipment at the same speed following the output of the speed control algorithm.
    d) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:
        (1) Where flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:
            (a) Determine initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.
        (2) When the “Stop Next” condition exists through a preset time delay:
            (a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
            (b) Stop the load once it reaches minimum speed.
            (c) Operate all remaining equipment at the same speed following the output of the speed control algorithm.

18. Gate and valve control:
    a. Monitor the device’s HAND-OFF-AUTO (HOA) switch(es) (the integral switch in the actuator or hard-wired switch at the HAND control station):
        1) Display current AUTO status on PCIS screens.

b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCIS AUTO, or OPEN was selected in PCIS HAND):
    1) Initially set “Open Activation” time to twice the normal opening time.
    2) If the HOA position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:
        a) De-activate the open output.
        b) Place the device in a “Failed” state.
        c) Generate a “Failed to Open” alarm.
c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCIS AUTO, or CLOSE was selected in PCIS HAND):
    1) Initially set “Close Activation” time to twice the normal closing time.
    2) If the HOA position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:
        a) De-activate the close output.
        b) Place the device in a “Failed” state.
        c) Generate a “Failed to Close” alarm.
d. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a “Position Error” timer whenever the position feedback differs from the required position command by more than a setpoint error when the HOA is in AUTO:
    1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
    2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
    3) Initially set the “Position Error” time to 60 seconds.
    4) If the HOA position does not change, and position error stays outside of the setpoint error through the “Position Error” time period:
        a) Hold position output.
        b) Place the device in a “Failed” state.
        c) Generate a “Position Fail” alarm.
e. Provide separate time delay settings for each function and for each device.
f. If the valve position inputs indicate an impossible state (i.e., valve open and closed at the same time), place the device in a “Failed” state and generate an “Illegal State” alarm.
g. Re-establish PLC control of a device in a “Failed” state only after one of the following:
    1) An operator turns the device’s HOA switch out of AUTO and back to AUTO (i.e., AUTO input to the PLC cycles off and back on).
    2) An operator acknowledges the fault from SCADA.
h. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
i. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE

outputs), count the number of actuations (OPEN or CLOSE commands) in the PLC:
1) Display count on the OIT.
2) Provide a reset function for the count.

19. Chemical systems (HMI/OIT):
    a. Provide the following chemical system screens:
        1) Where one HMI manages more than one chemical system, a main menu screen that will allow the operator to access the individual chemical system screens using software keys.
        2) One or more screens for each individual chemical system controlled at that location, containing:
            a) All status displays (running, failed, etc.).
            b) Selections (lead/lag, which process flow to pace to, etc.).
            c) Setpoint entry and display.
            d) Calculated feed requirement (result of flow pacing calculation) in engineering units (typically milligrams of chemical per minute).
            e) Output signal to feeder in percent of full span.
            f) Actual chemical flow rate from flowmeter (where shown).
            g) Process flow rate(s) used to pace each chemical on the individual chemical screens (PROC FLOW):
                (1) Where different process flows can be selected for flow pacing, display and identify the selected source.
        3) Chemical system calculations: Perform calculations as indicated on the Drawings and in the individual loop descriptions. Use the following assumptions, unless otherwise noted.
        4) Where chemical flow feedback is not used, assume feeder output is linear in response to control signal.
        5) Zero signal (typically 4 milliamperes) produces zero flow.
        6) Perform flow-pacing calculations using as indicated on the Drawings or described in the individual loop descriptions.
    b. Provide the setpoints and selections indicated on the Drawings and in the individual loop descriptions. Typical setpoints include:
        1) QMAX: Maximum calibration value:
            a) Chemical flow rate measured from calibration column at maximum feeder output (typically in gallons of solution per hour or milliliters of solution per minute).
        2) CONC: Chemical concentration:
            a) The concentration of the chemical in the solution to be fed, in engineering units (typically milligrams of chemical per liter of chemical solution).
        3) DENSITY:
            a) Density of the chemical solution to be fed in engineering units or as a specific gravity.
            b) Used to calculate the concentration of the chemical in the solution.
        4) DOSE: Desired dosage:
            a) Desired chemical concentration in the process stream in engineering units (typically milligrams of chemical per liter of process fluid).
        5) FLOW SEL: Selection of process stream(s) for flow pacing.
        6) OPEN/CLOSED LOOP:

a) Selection of method of controlling chemical flow-paced feed rate.
b) OPEN LOOP: Signal to feeder is based on feeder calibration (QMAX) to deliver calculated chemical solution feed rate. Chemical solution flowmeter is not used for control.
c) CLOSED LOOP: Chemical feed rate is directly controlled using the calculated chemical solution feed rate as the setpoint, and the flow rate from the chemical solution flowmeter as the process variable.

c. Chemical control algorithms:
1) Flow pacing algorithm: Operator selects a desired dose and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, and feeder calibration. The calculation is as follows (units may vary from those shown in the calculation below):

$$FEEDER\ FLOW\ (\frac{ml}{min}) = \frac{21.948 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW(MGD)}{CONC\left(\frac{lb}{gal}\right)}$$

$$FEEDER\ FLOW\ (\%) = \frac{FEEDER\ FLOW(\frac{ml}{\min})}{QMAX(\frac{ml}{\min})}$$

2) Flow pacing with closed loop algorithm: Operator selects a desired dose and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint. This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage and concentration. The calculation is as follows (units may vary from those shown in the calculation below):

$$\boldsymbol{FEEDER\ FLOW\ (\frac{ml}{min}) = \frac{21.948 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW(MGD)}{CONC\left(\frac{lb}{gal}\right)}}$$

a) Adjust the speed of the chemical feeder using a PID control algorithm to maintain the calculated FEEDER FLOW:
(1) SP = Calculated FEEDER FLOW.
(2) PV = Chemical Flow.
(3) CV = Speed of the Chemical Feeder.

3) Flow pacing with analyzer trim algorithm: Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, process analyzer output, and feeder calibration. The calculation is as follows (units may vary from those shown in the calculation below):

$$\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\frac{\boldsymbol{21.948}*\boldsymbol{DOSE}\left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right)*\boldsymbol{PROCESS\ FLOW}(\boldsymbol{MGD})}{\boldsymbol{CONC}\left(\frac{\boldsymbol{lb}}{\boldsymbol{gal}}\right)}$$

$$\boldsymbol{TRIM\ MULTIPLIER}=\frac{\boldsymbol{AI}-\frac{\boldsymbol{1}}{\boldsymbol{2}}(\boldsymbol{QAH}+\boldsymbol{QAL})}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}(\boldsymbol{QAH}-\boldsymbol{QAL})}$$

Clip the trim multiplier output to a maximum of 1 and minimum of -1.

$$\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\boldsymbol{0.10}*\frac{\boldsymbol{AI}-\frac{\boldsymbol{1}}{\boldsymbol{2}}(\boldsymbol{QAH}+\boldsymbol{QAL})}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}(\boldsymbol{QAH}-\boldsymbol{QAL})}*\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

$$\boldsymbol{FEEDER\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)+\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

$$FEEDER\ FLOW\ (\%)=\frac{FEEDER\ FLOW(\frac{ml}{\min})}{QMAX(\frac{ml}{\min})}$$

4) Flow pacing with closed loop and analyzer trim algorithm: Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint. An additional control algorithm is used in the calculation to fine-tune the feed based on an analytical measurement as measured by the process analyzer.

$$\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\frac{\boldsymbol{21.948}*\boldsymbol{DOSE}\left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right)*\boldsymbol{PROCESS\ FLOW(MGD)}}{\boldsymbol{CONC}\left(\frac{\boldsymbol{lb}}{\boldsymbol{gal}}\right)}$$

$$\boldsymbol{TRIM\ MULTIPLIER}=\frac{\boldsymbol{AI}-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH+QAL)}}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH-QAL)}}$$

Clip the trim multiplier output to a maximum of 1 and minimum of -1.

$$\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\boldsymbol{0.10}*\frac{\boldsymbol{AI}-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH+QAL)}}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH-QAL)}}*\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

$$\boldsymbol{FEEDER\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)+\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

a) Adjust the speed of the chemical feeder using a PID control algorithm to maintain the calculated FEEDER FLOW:
   (1) SP = Calculated FEEDER FLOW.
   (2) PV = Chemical Flow.
   (3) CV = Speed of the Chemical Feeder.

d. Virtual day tanks:
   1) Most chemical systems will have their own “virtual” day tank, which will use either a pre-set volume (operator adjustable) or a calculated daily use rate based on the totalized flow (volume) of the chemical magnetic flowmeters over the virtual day tank cycle. The “virtual” day tank will start at the pre-set volume or the calculated volume (operator-selectable) and based on the storage tank level, the volume in the “virtual” day tank will decrease until the total “volume” in the virtual day tank is used. The virtual day tank will automatically compensate for any changes in the system due to the use of the dilution system (revised solution concentration). Once this occurs, the operator will be provided with a “pop-up” screen stating that the “virtual” day tank volume is used. Once this occurs, the operator will be provided with a “pop-up” screen stating that the virtual day tank needs to be refilled. The pop-up screen will contain the following information:
      a) Time {hours and minutes} since the last day tank filling.
      b) Volume utilized in the “virtual” day tank (based on the level transmitter measuring the chemical storage tank).
      c) Dose {mg/L} based on the average flow rate over the “virtual” day tank cycle.

d) Target dose {mg/L} based on operator input.

2) Provide a double check using the actual flowmeter values to compare with the calculated dose. Compared the magnetic flowmeter value with the calculated dose. The magnetic flowmeter value will be based on an hourly average of chemical flow rate over the day tank cycle.

3) As an added level of control any chemical system that has an analyzer used for feedback will be tracked and alarmed if outside the operating parameters.

4) Alarm if any condition falls outside of the flow, or level parameters.

20. Breaker status:
    a. Display the following data to the extent it is available from the specified device:
        1) Open.
        2) Closed.
        3) Tripped.
        4) Ground fault.
21. Power and starter information:
    a. Retrieve data via power quality meters, motor protection relays, digital bus networks, or metering instruments, as indicated.
    b. Display the following data to the extent it is available from the specified device:
        1) Current: XXXX.X A:
            a) A-Phase.
            b) B-Phase.
            c) C-Phase.
        2) Volts: XXXX.X V:
            a) A-Phase.
            b) B-Phase.
            c) C-Phase.
        3) Reactive power: XXXX.X kVAR.
        4) Real power: XXXX.X kW.
        5) Apparent power: XXXX.X kVA.
    c. For engine/generator system monitoring, also display percent of rated output.
22. Starters and VFDs equipped with digital bus communications:
    a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below.
    b. Communicate start and stop commands, and receive running feedback over the fieldbus network.
    c. Monitor the following additional values, and display on the OIT:
        1) Motor current, phase A, B, and C.
        2) Over current alarm.
        3) Under current alarm.
        4) Running status.
        5) Phase loss.
        6) Stall.
        7) Number of starts**.**
        8) History of past 5 trips.
    d. For Variable Frequency Drives:
        1) Speed command.
        2) Speed feedback.

e. For Variable Frequency Drives, and where otherwise shown or available, monitor the following over the digital bus network:
    1) Line voltage.
    2) Power.
    3) Power factor.
    4) Over voltage alarm.
    5) Under voltage alarm.
    6) Over current alarm.
    7) Under current alarm.

23. Instruments equipped with digital bus communications:
    a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below.
    b. Instrument diagnostics.
    c. Communications health.
    d. Process variable.
    e. Alarm summary.
24. Valves and gate operators equipped with digital bus communications:
    a. Communicate and display all controls and data listed in the equipment specification, as indicated on the Drawings, or listed below:
        1) Open, close or direct position commands.
        2) Fully open and closed status.
        3) Position.
        4) High torque, overload and other applicable alarms.
    b. Establish initial torque curves using manufacturer's software for performance tracking and wear.
25. Plant shutdown:
26. Power failure:
    a. Retain all operating setpoints during power failure.
    b. Restore plant operation to the state it was before the power loss:
        1) Store the operating state of all major equipment and systems in the PLC, and retain the last state during a power loss.]
        2) When transferring to generator power, provide a load sequence table on the OIT and HMI showing the major equipment and systems, and providing a "re-start" selection.
            a) For each item, list the following:
                (1) Equipment name and tag.
                (2) Running kW and kVA.
                (3) Starting kW and kVA.
                (4) Identify whether it was running immediately before the power loss.
                (5) Show current running and available status.
                (6) Operator selection to re-start:
                    (a) Do not allow selection of loads that will cause the generator starting or running capacity to be exceeded.
                    (b) Insert a sequence number showing the order in which the load was selected. If a load is selected again, remove it from the queue, and update the sequence numbers for the remaining equipment.]]
            b) When operating on generator power, also display the following, updating as selections are made, and as load:
                (1) Generator(s) operating.
                (2) Generator(s) available.

(3) Remaining running and starting kW and kVA:
(a) Calculate from measured generator output kW and kVA, and the maximum starting and running capacity required to start the selected loads.]

c) [Once the operator has selected loads, and selected “re-start”:
(1) Start the process loads in the order they were selected.
(2) Use the logic described above for preventing concurrent starts to provide necessary delays between each step.

d) After the initial loads have been sequenced on, allow automatic operation to continue to stop and start loads [within generator capabilities.

c. Provide an operator selection to permit the plant to re-start. Once re-start is selected:][Allow plant loads to re-start, and allow loads to sequence on and ramp up following normal control logic. Where loads were operating in PCIS HAND, restore their operation to the state before the power loss:
1) Use the logic described above for preventing concurrent starts to provide necessary delays between each start.

d. Operating on generator power:
1) Include running and starting kW and kVA requirements for each major equipment and system in registers in the PLC:
a) Where running load can vary due to speed, valve position, etc., use the normal starting value plus 25 percent of the difference between the maximum and minimum values.
2) Inhibit starting of loads from process control logic and from operator selection (in PCIS HAND) that will exceed generator capability.
3) Generate the following alarms:
a) Generator near capacity: When measured kW or kVA reaches 90 percent of the rating of [running generators] [the generator].
b) Generator at capacity: When measured kW or kVA reaches 95 percent of the rating of [running generators][the generator].
c) Unable to start: When an operator selects a load that would exceed generator starting or running capacity.
d) Insufficient capacity: When the control system needs to start a load, but is inhibited due to generator capacity.
4) Whenever the Generator at Capacity alarm is active, inhibit starting of any loads, and inhibit increase in speed of all control loops, and other changes that would increase electrical load.
5) For multiple generator systems, coordinate capacity alarms and equipment starting with generator control system to ensure adequate generator capacity, and to prevent alarms.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17101

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Loop descriptions and specific control requirements and functional descriptions for individual control loops.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Section 01330 and Section 17050.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual clarifiers, only one loop description need be developed and the remaining loops may reference that loop description.

B. Loop description format:
   1. Loop number and title.
   2. References: List P&IDs that are specifically referenced.

3. Abstract:
    a. General description of how the loop works, what devices are involved, and how the process will be controlled.
    b. Process values, setpoints, and limits, including units and ranges: Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.
4. Hardwired control:
    a. Detailed description of the control functions at the local level.
    b. Function of local operator interfaces.
    c. Operation of hardwired field pilot controls:
        1) Pushbuttons.
        2) Selector switches.
        3) Potentiometers.
        4) Pilot lights, indicators, and other displays.
5. Hardwired interlocks: Explanation of the operation of system interlocks and hardwired permissive conditions.
6. PLC control:
    a. Detailed description of the control functions that are under control of the PLC.
    b. Operator controls and automatic controls.
    c. Setpoints, alarms, etc.:
        1) Include units and ranges for analog values.
        2) Include span and range for analog inputs and outputs.
        3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
    d. Control sequences.
7. Software interlocks: Operation of system software interlocks.
8. HMI control: Detailed description of the operator controls.
9. SCADA control:
    a. Detailed description of the operator controls.
    b. Setpoints, alarms, etc.
10. Indicators and alarms: List any indicators and alarms specific to the loop that are not covered in the common control strategies.
11. Failure modes: List any failure modes specific to the loop that are not covered in the common control strategies.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. **Injection Wells No.1 and No.2 Controls:**
1. References:
    a. 40-N-01.
    b. 50-N-02.

2. Abstract:
   a. Injection Well's in Hand Mode:
      1) With the HOA in "Hand" the Injection Well pump can be started and stopped locally at the Well Starter. This mode of operation is typically only used for maintenance purposes. Normal operation will be Automatic mode.
   b. Injection Well's in Automatic Mode: The Injection Wells has three mode cycles of operation (Flush, Recharge and Backflush).
      1) The start-up sequence begins with the **Flushing Cycle**:
         a) Well goes through a flushing cycle immediately before a recharge cycle to purge air and pump out sand or other debris.
         b) Verify flushing valve is in the OPEN position.
         c) Verify recharge valve is in the CLOSED position.
         d) Start the Well Pump. This will initiate the OPENING of oil lubrication solenoid bypass valve, allowing additional flow to the bearings. A lube timer will begin for a period of 1 minute before the Well Pump is started.
         e) Once the Well Pump is started an operator- adjustable flush time will initiate for period of X minutes before transiting to Recharge Mode.
      2) The transition to **Recharge Cycle**:
         a) OPEN recharge valve with the Injection Well Pump running.
         b) Turn on injection well supply pump. Water from both the well and the supply pump station will flow through flush line during this step. Stay on this step for X minutes before proceeding to ensure all air is purged from line and to flush any particulates in the pipeline through the flush line.
         c) Turn ON chlorine metering pumps (flow and residual paced)
         d) Turn off Injection Well Pump.
         e) After X minute delay close flushing valve.
      3) The transition to **Backflush Cycle**:
         a) A backflush cycle is automatically initiated after X hrs of recharge. The backflush cycle lasts for X hrs. Alternately, a backflush cycle is automatically initiated if the specific capacity setpoint is reached.
            (1) **Specific capacity calculation:**
            SC = Q/D where
            SC = specific capacity, gpm/ft
            Q = injection rate (as measured by the flow meter at the well), gpm
            Hm = Mounding height, ft = water level during injection - static water level

            SC setpoint = X gpm/ft (initiates a backflush cycle)--TBD based on testing
         b) Once specific capacity setpoint is reached preform the following:
            (1) Shutdown Injection Well Supply Pump(s)
            (2) Shutdown chlorine metering pump
            (3) Open flush valve
            (4) Close recharge valve
            (5) Start Injection Well Pump (run for operator-adjustable time X hrs)

c) Unless Injection Well is taken off-line, the Injection Well should automatically transition back to recharge cycle after a flush cycle.

4) A lead/lag function needs to automatically alternate the injection wells after 1 cycles (adjustable). Operators will need the ability to turn this function off so they can run both wells simultaneously if desired.

c. When an operator selects "STOP" to shut down the Injection Well from the HMI or SCADA screen during a **recharge** cycle, the following sequence should occur:
   1) Shut down injection well supply pump (s)
   2) Shut down chlorine metering pump
   3) Open flush valve
   4) Close recharge valve

d. When an operator selects "STOP" to shut down the Injection Well from the HMI or SCADA screen during a **backflush** cycle, the following sequence should occur:
   1) Shut down injection well pump
   2) Flush valve remains open
   3) Recharge valve remains closed

e. If Injection supply pumps shut down due to power loss or failure, an alarm condition, the following sequence should occur:
   1) Close recharge valve
   2) Open Flushing valve

3. Hardwired equipment permissive:
   a. Backspin Timer, after the Injection Well pump stops, it will be inhibit from restarting until after the backspin timer has elapsed.
   b. Oil Lube Timer, on any start (or restart) command the pump an oil lube solenoid valve will open and a 1 minute lube timer will initiate. After the lube timer has elapsed the Injection Well pump will start.

4. Hardwired equipment interlocks:
   a. On high discharge pressure, the Injection Well pump will stop.
   b. On high motor winding temperature, the Injection Well pump will stop.
   c. Softer Starter fault, the Injection Well pump will stop.
   d. Motor operated valve actuators are equipped with high torque limits that will stop valve operation.
   e. All pump hardwired interlock will require a local reset.

5. PLC software interlocks:
   a. If flushing valve is not opened and the recharge valve is not closed, the Injection Well Pump should not start.
   b. If the lube oil drum is low, the Injection Well Pump should not start.

6. Indicators and alarms:
   a. All Injection Well Pump indication and faults as depicted on P&IDs shall be available locally at respective panels, on the injection supply pump station HMI, and the Plant's existing SCADA system.

b. Radio communication failure shall be available at both the injection supply pump station HMI and Plant's existing SCADA system.

B. **Injection Well Supply Pump Station Controls:**

1. References:
   a. 20-N-01.
2. Abstract:
   a. Injection Well Supply Pump Station in Hand Mode:
      1) The HOA in "Hand" the supply pumps can be started and stopped locally at the pump's respective VFD panel. This mode of operation is typically only used for maintenance purposes. Normal operation will be Automatic mode.
   b. Injection Well Supply Pump Station in Automatic Mode:
      1) The HOA in "Auto" the supply pumps can be started and stopped at the pump station local HMI screen or the Plant's SCADA screens.
   c. The wetwell receives disinfected water from the UV channels. The pump station supplies Class A+ reclaimed water to the Injection Wells. If full, water will overflow a weir into the existing Area 1-3 Irrigation Pump Station wetwell. The pumps are sized such that one supply pump will meet the injection capacity of one well.
   d. Pump Speed Control:
      1) Pumps are equipped with VFDs. The PLC will vary the pump speed to meet the flow setpoint. The flow readings will be determined from the flow meters at the Injection Well sites.
   e. The wetwell level (levels are relative to the floor of the wetwell)
      1) High-high level (9.5 ft): Alarm
      2) High level (8.5 ft): Alarm
      3) Low level (1.5 ft): Alarm
      4) Low-low level (0.5 ft): Alarm and shut down supply pumps
   f. Alternate supply pumps operation to maintain similar run times.
   g. Each pump should be dedicated to a certain well in the software, such that if one well is operating, and the second well is started, a second supply pump will be brought on-line.
3. Hardwired equipment permissive:
   a. None.
4. Hardwired equipment interlocks:
   a. On high discharge pressure, the supply pump will stop.
   b. On high motor winding temperature, the supply pump will stop.
   c. Wet well low-low level, the supply pump will stop.
   d. VFD fault, the supply pump will stop.
   e. All pump hardwired interlock will require a local reset.
5. PLC software interlocks:
   a. If the active injection well recharge valve is not opened, the supply pump should not start.
6. Indicators and alarms:
   All Injection Supply Pump indication and faults as depicted on P&IDs shall be available locally at respective panels, on the injection supply pump station HMI, and the Plant's existing SCADA system.

Sodium Hypochlorite Metering Pump Controls:

7. References:
   a. 30-N-01.

8. Abstract:
   a. The pumps are provided as part of the on-site sodium hypochlorite generation system package. The purpose for the sodium hypochlorite system is to provide biofilm control at the injection well. Sodium hypochlorite is stored in the solution tank and pumped to the injection well supply line feed point, where it mixes with the reclaimed water being supplied to the wells. A chlorine residual analyzer is located at Well No. 1 and will be used in the control strategy for chlorine feed rate to both wells.
   b. Chlorine dose is calculated to match residual setpoint based on signals from recharge flow meter and residual analyzer at the well sites.
   c. Duty metering pump starts automatically when injection well supply pumps start.
   d. Calculation (for Well No. 1 feed rate):
      1) Feed Rate (gpm) = $(Q_1 \times C_{i1})/C_s$
         where
         Q_1 = Injection well supply flow, gpm (as measured by Well No. 1 recharge flow meter)
         C_{i1} = Initial concentration setpoint for Well No. 1, mg/L, default = 7.0 mg/L
         C_s = Concentration of sodium hypochlorite product, mg/L, default = 4,500 mg/L
   e. Calculation (for Well No. 2 feed rate):
      1) Feed Rate (gpm) = $(Q_2 \times C_{i2})/C_s$
         where
         Q_2 = Injection well supply flow, gpm (as measured by Well No. 2 recharge flow meter)
         C_{i2} = Initial concentration setpoint for Well No. 2, mg/L, default = 7.5 mg/L
         C_s = Concentration of sodium hypochlorite product, mg/L, default = 4,500 mg/L
   f. Target total chlorine residual is 1.0 mg/L (adjustable). After X minutes, the PLC calculates the difference between the target residual and the measured residual.
      1) If the measured residual is higher than 0.2 mg/L (adjustable) above the target residual, the PLC recalculates the feed rate as follows:
         Feed Rate (gpm) = $(Q \times C_{rev})/C_s$
         where
         Q = Injection well supply flow, gpm (as measured by Well No. 2 recharge flow meter)
         C_{rev} = Adjusted concentration, mg/L = $C_i + (R_t - C_m)$
         R_t = Target residual, mg/L, default = 1.0 mg/L (Well No. 1); 1.5 mg/L (Well No. 2)
         C_m = measured concentration, mg/L
         C_s = Concentration of sodium hypochlorite product, mg/L, default = 4,500 mg/L
      2) If the chlorine analyzer measurement is zero (0) mg/L, then the PLC should increase Ci by 0.2 mg/L, and recalculate feed rate.

9. Hardwired equipment permissive:
   a. None.
10. Hardwired equipment interlocks:
   a. On high discharge pressure, the supply pump will stop.

b. On high motor winding temperature, the supply pump will stop.
c. Wet well low-low level, the supply pump will stop.
d. VFD fault, the supply pump will stop.
e. All pump hardwired interlock will require a local reset.

11. PLC software interlocks:
    a. If the active injection well recharge valve is not opened, the supply pump should not start.
12. Indicators and alarms:
    All Injection Supply Pump indication and faults as depicted on P&IDs shall be available locally at respective panels, on the injection supply pump station HMI, and the Plant's existing SCADA system.

C. **Sodium Hypochlorite Generator Controls:**

1. References:
   a. 30-N-01.
2. Abstract:
   a. Refer to MOIX System manufacturer for details.
3. Indicators and alarms:
   All Sodium Hypochlorite Generator System indication and faults as depicted on P&IDs shall be available locally at generator panel, on the injection supply pump station HMI, and the Plant's existing SCADA system.

D. **Well Site Intrusion Remote Alarming:**

1. References:
   a. 40-N-01.
   b. 50-N-01.
2. Abstract:
   a. Intrusion switches are located at access doors and gates. Switches are tied together in series and connected directly to PLC input so that a break in any of the switches is disabled an adjustable delay time (default 60 seconds) in the PLC program.
   b. If "Disable Key Switch" is switched to "Disable" within the delay time the remote intrusion SCADA alarm is disabled.
   c. If "Disable Key Switch" is not switched to "Disable" within the delay time the remote intrusion SCADA alarm annunciated at both the Plant Screen and Win-911 remote alarm system.
   d. Reactivate intrusion system when the "Disable Key Switch" is switched to "Enable" after an adjustable delay time (default 2 minutes) in the PLC program.

3.02 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT – SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Conductivity level switch.
   2. Ball float level switch.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.

2. Physical conditions:
    a. Installation and mounting requirements.
    b. Location within the process.
    c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
    1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
    1. Conductivity level switch:
        a. Gems Sensors and Controls/Warrick series.
        b. Ametek B/W Controls 6013 electrode series.
    2. Ball float level switch:
        a. Siemens Water Technologies Corp 9G-EF.
        b. ITT Flygt Model ENM-10.
        c. Anchor Scientific Incorporated Ecofloat/Solofloat.

2.02 MANUFACTURED UNITS

A. Conductivity level switch:
    1. General:
        a. Probe type conductivity level switches integrating a control relay, control and reference electrode probes as required, and electrode probe holder. Unless otherwise specified in the ISA data sheets, electrode probes shall be rigid stainless steel and probe holder pressure-tight.
        b. All components provided by the same manufacturer.

2. Element:
    a. Rigid type: For probe lengths of 6 feet and less provide Type 316 stainless steel rigid probes unless otherwise specified in the instrument schedule ISA Data Sheets. Electrode probe shall be threaded at one end to fit electrode holder threads and insulated with 1/32 inch PVC sheath down to 1 inch from the other end.
    b. Electrode probe holder.
    c. Suspended probes: For probe lengths longer than 6 feet, provide wire suspended probes within a protective plastic shield suspended and PVC insulated wires. Provide suitable adapters for fastening upper end to electrode fitting.
3. Switch: The control relay senses the liquid level by conductance through electrode probes and the process liquid:
    a. Provide a solid-state general-purpose control relay designed for single level or differential control.
    b. Electrical connection: One 1/2 inch NPT conduit entry.
    c. Power supply:
        1) 24 VDC.
        2) Power consumption: 10 VA maximum.
    d. SPDT contacts rated 5 amps resistive at 120 VAC.
    e. Secondary voltage (applied to electrodes): 12 VAC, 1.5 mA maximum.
    f. Enclosure: NEMA Type 4X.
4. Components:
    a. Adjustable time delay on increasing or decreasing level.
    b. Manufacturers: One of the following or equal:
        1) Standard applications:
            a) Warrick Controls Model or 16 VM.
            b) B/W Control High Sensitivity Series 5200.
        2) Intrinsically Safe:
            a) Warrick Controls Model 27.
            b) B/W Control High Sensitivity Series 5200 N7
5. Approvals:
    a. Class I Div 2.
    b. If wired as intrinsically safe - Class I, Div 1, Groups A, B, C & D.

B. Ball float level switch:
1. General:
    a. Free hanging, encapsulated body with a switch to determine position of float.
2. Element:
    a. Mechanical switch encapsulated in waterproof floating polypropylene ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
    b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.
    c. Float: Provide Type 316 stainless steel, minimum 3 inches in diameter. The float shall provide a minimum of 2 pounds of buoyancy in solutions with specific gravity of 1 and shall have an operating temperature rating of -30 degrees Fahrenheit to +150 degrees Fahrenheit.
    d. Mercury switches are not acceptable.
    e. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.

3. Switch:
    a. Single pole double throw contacts rated 10 amps resistive at 120 VAC.
    b. Provide the number of floats per level system as indicated on the Drawings.
    c. Suspend ball float and adjust for level setpoint as required.
4. Components:
    a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4 inch cable to allow testing of the float without entering the basin or wet well.
    b. Provide strain relief at both ends of the float cable.
    c. Float anchors:
        1) Furnish 15-pound PVC coated anchor kit with 10 feet of Type 316 stainless steel chain.
        2) Provide stainless steel shackles and float clamps.
        3) Manufactured by:
            a) Conery Mfg. Inc.
            b) Approved equal.
5. Approvals:
    a. Class I Div 2.
    b. If wired as intrinsically safe - Class I, Div 1, Groups A, B, C & D.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installation.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
    1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. AS SPECIFIED IN SECTION 17050.

3.04 FIELD QUALITY CONTROL

A. AS SPECIFIED IN SECTION 17050.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, as specified in the Specifications or both.

END OF SECTION

SECTION 17206

LEVEL MEASUREMENT - ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ultrasonic level instruments.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. FDT: Field Device Tool.
   2. DTM: Device Type Manager.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One the following no equal:
   1. Ultrasonic Level sensor with 4-wire remote transmitter:
      a. Siemens: Echomax Series sensor with HydroRanger 200 Series Transmitter.
      b. Or approved equal.

2.02 MANUFACTURED UNITS

A. Ultrasonic level measurement with 4-wire remote transmitter:
   1. General:

a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo or ranging technique sensing. Each 4-wire level transmitter system may include, but is not limited to:
    1) Ultrasonic Transducer.
    2) Signal cable.
    3) Transmitter.
    4) Transceiver.

2. Performance requirements:
    a. Accuracy:
        1) 0.25 percent of range.
    b. Repeatability:
        1) 0.1 percent of range.
    c. Royce model level resolution:
        1) .1 feet to 25’ depth, .2 feet to 50’ depth, .3 feet to 75’ depth.
    d. Royce Stability:
        1) .1% per degree centigrade.
3. Ultrasonic transducer:
    a. Encapsulated in chemical and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument index.
    b. Class I, Division 1 for transducer only except for Royce model.
    c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius) or -30 to 80 degrees C for Royce model.
    d. Operating relative humidity range: 5 to 95 percent or 0 to 100 percent for Royce model.
    e. Functions:
        1) Temperature compensation or none for Royce model.
    f. Mounting: As indicated in the Contract Documents.
4. Transmitter:
    a. Level indicating transmitter:
        1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
        2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
        3) Ability to allow for signal profiles and echo mapping:
            a) Provide manufacturers software for re-mapping the signal.
    b. Functions:
        1) Level measurement.
        2) Tank volume.
    c. Power supply:
        1) 120 VAC.
        2) Power consumption: 36 VA maximum.
    d. Outputs:
        1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
        2) 1ea isolated 4 to 20 milliamperes DC scaled to any range (Royce model).
        3) 1ea isolated 4 to 20 milliamperes DC relative clarity of top four feet of tank (Royce model)
        4) 1ea Digital serial interface either RS 232 or RS 485 (Royce model).
        5) Relay outputs:
            a) 3 Form A or Form C contacts.

b) Rated 5 amps at 120 VAC.
c) Programmable.

6) Enclosure: NEMA Type 4X
7) Mounting: As indicated in the Contract Documents.
8) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius), (-10 to 50 degrees Celsius for Royce model) relative humidity of 10 to 100 percent.

2.03 ACCESSORIES

A. Mounting brackets: As indicated on the Drawings.

B. Provide sunshades for outdoor installations.

C. Provide handheld programmers for all transmitters.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17302

FLOW MEASUREMENT - MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Full-body magnetic flowmeters.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

A. As specified in Section 17050.

B. NSF International (NSF).

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.

c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Rosemount: 8700E.
   2. Or approved equal.

2.02 MANUFACTURED UNITS

A. Magnetic flowmeter:
   1. General:
      a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
      b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
      c. Include for each magnetic flow metering system:
         1) A metering tube with electrodes (sensor).
         2) Signal cable.
         3) Transmitter integral or remote as indicated on the Drawings.
         4) Flowmeter grounding rings.
   2. Performance requirements:
      a. Accuracy:
         1) 0.25 percent of flow rate from 10 to 100 percent of full scale for velocities ranging between 1.9 to 10 feet persecond.
      b. Repeatability:
         1) 0.25 percent of rate.
   3. Element:
      a. Metering tube:

1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
2) Liner material in conformance with:
   a) Manufacturer's recommendations for the intended service.
   b) NSF certified for all drinking water applications.
3) Electrodes type and material in conformance with:
   a) Manufacturer's recommendations for the intended service.
   b) Utilize a minimum of 2**,** self-cleaning electrodes.
4) Meter terminal housing NEMA Type 4X unless specifically noted otherwise.
5) Meter coating consisting of epoxy painted finish.
6) Components:
   a) 2 grounding rings:
      (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
      (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.

4. Transmitter:
   a. Power supply:
      1) 120 VAC.
      2) Power consumption: 60 VA maximum.
   b. Outputs:
      1) As noted in the instrument data sheets.
      2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
   c. Microprocessor-based signal converter/transmitter.
   d. Utilize DC pulse technique to drive flux-producing coils.
   e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
   f. Operator keypad interface.
   g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
   h. Integral low flow cut-off zero return.
   i. Programmable parameters including:
      1) Meter size.
      2) Full-scale flow rate.
      3) Magnetic field frequency.
      4) Time constant.
   j. Data retention for a minimum of 5 years without auxiliary main or battery power.
   k. Self-diagnostics and automatic data checking.
   l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
   m. Transmitter housing NEMA Type 4X unless specifically noted otherwise. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

2.03 ACCESSORIES

A. Stainless steel tag labeled as specified in the Contract Documents.

B. Provide sunshades for all transmitters located outdoors.

C. Provide galvanic isolation gaskets, nylon/Teflon flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

D. Furnish 1 spool piece for every size of magnetic flow tube being provided.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each flow metering system at a facility that is traceable to the NIST.

C. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
   1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
   2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
   3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer’s services to perform installation inspection.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments.

B. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17401

PRESSURE/VACUUM MEASUREMENT - DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.
   2. Annular seals.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Additional requirements:
   1. Product data:
      a. Manufacturer's installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of contract documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      A. Installation and mounting requirements.
      B. Location within the process.
      C. Accessories: verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

B. Provide spare annular seal for every size indicated in the project.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Diaphragm seals:
   1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
      a. Ashcroft:
         1) Flushing connection: Type 741.
         2) Without flushing connection: Type 740.
      b. Mansfield and Green:
         1) Flushing connection: Type SGT.
         2) Without flushing connection: Type SBT.
      c. Wika, Type L990.40.
      d. Rosemount.

2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
    a. Ashcroft:
        1) Flushing connection: Type 201.
        2) Without flushing connection: Type 200.
        3) Saddle mount: Type 205.
    b. Mansfield and Green:
        1) Flushing connection: Type SG.
        2) Without flushing connection: Type SB.
        3) Saddle mount: Type SJ.
    c. Wika:
        1) Type L990.10.
        2) Saddle mount: L910.ZA]
    d. Rosemount.

B. Annular seals:
    1. One of the following or equal:
        a. Ashcroft Iso-Ring.
        b. Onyx Valve.
        c. Red Valve.

2.02 MANUFACTURED UNITS

A. Diaphragm seals:
    1. General:
        a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
    2. Requirements:
        a. Seal type:
            1) Metallic diaphragm: Welded to upper housing.
            2) Elastomer diaphragm: Bonded to upper housing.
        b. Process connection: 1 inch NPT.
        c. Instrument connection: 1/2 inch NPT.
        d. Material Construction: Type 316 Stainless Steel**.**
        e. Provide fill/bleed connection.
        f. Mounting: As indicated in the Contract Documents.
        g. Provide Type 316 stainless steel armored capillary for all remote installations.
        h. Nuts and bolts: Type 316 stainless steel.
        i. Materials of construction:
            1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
                a) Diaphragm: Type 316 stainless steel.
                b) Lower housing: Type 316 stainless steel.
                c) Upper housing: Manufacturer’s standard.
                d) Fill fluid: Silicon oil.
            2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
                a) Diaphragm: Type 316 stainless steel.
                b) Lower housing: Type 316 stainless steel.

c) Upper housing: Manufacturer's standard.
d) Fill fluid: Silicon oil.

3) Ferric chloride:
a) Diaphragm: PTFE or tantalum.
b) Lower housing: PVC or titanium.
c) Upper housing: Manufacturer's standard.
d) Fill fluid: Silicon oil.

4) Sodium hypochlorite:
a) Diaphragm: Tantalum.
b) Lower Housing: Titanium.
c) Upper Housing: Manufacturer's standard.
d) Fill Fluid: Halocarbon.

5) Engineer's approval.

B. Annular seals:
1. General:
a. Inside diameter of annular seal shall provide uninterrupted flow:
1) There shall be no dead ends or crevices.
2) Process flow shall be sufficient to make the annular seal self-cleaning.
b. The pressure sensing flexible cylinder shall measure pressure around the full inside circumference of the pipeline.
2. Requirements:
a. Pressure rating: Equivalent to the ANSI flanges.
b. Materials of construction:
1) Inner flexible cylinder: Manufacturer's standard.
2) Body:
a) Carbon Steel with epoxy coating
3) Assembly flanges: To match adjacent piping.
4) Fill fluid: Silicon oil.
c. Nominal pipe size: As indicated on the Drawings.
d. Process connection: Class 150 Raised Face Flange.
e. Instrument connection: 1/2 inch NPT.

2.03 ACCESSORIES

A. Provide field fill kits.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Do not use Teflon thread seal tape on pressure instruments with silicon oil fill fluid.

3.04 FIELD QUALITY CONTROL

A. As specified In Section 17050.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the contract documents:
   1. Instruments may be indicated on the Drawings, in the Specifications or both.

END OF SECTION

SECTION 17402

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve manifolds and instrument valves.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

C. Additional requirements:
   1. Product data:
      a. Valve type.
      b. Body material.
      c. Size.
      d. Options.
   2. Shop drawings:
      a. Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Valve manifold manufacturers: One of the following or equal:
   1. Anderson Greenwood.
   2. Hex Valve.

3. Noshok.
4. Rosemount.

B. Block and bleed valve manufacturers: One of the following or equal:
1. Anderson Greenwood.
2. Hex Valve.

C. Gauge valve manufacturers: One of the following or equal:
1. Anderson Greenwood.
2. Hex Valve.

D. Level sensor isolation valve manufacturers: One of the following or equal:
1. Indu-Tech Level Sensor Isolation Valve.
2. DeZURIK Level Sensor Isolation Valve.
3. Tyco Rovalve Isolation Knife Gate Valve.

2.02 MANUFACTURED UNITS

A. Valve manifolds:
1. General:
a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
2. Requirements:
a. Bonnet lock pin to prevent accidental loosening.
b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
e. Manifold valves shall allow for direct or remote instrument mounting.
f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
g. Materials of construction:
1) Body material: Type 316 stainless steel.
2) O-Ring: Teflon.
h. 2-Valve manifolds:
1) 1 isolation valve and 1 drain/vent and calibration valve.
i. 3-Valve manifolds:
1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
2) Plugged vent connections used for vent/drain or calibration.
j. Blowdown 5-valve manifold:
1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
k. Metering 5-valve manifold:
1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.

B. Block and bleed valves:
1. General:
a. Valve shall provide process isolation and venting/draining capabilities.

b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.

2. Requirements:
a. Materials of construction:
1) Body material: Type 316 stainless steel.
2) O-Ring: Teflon.

C. Gauge valves:
1. General:
a. Valve shall provide process isolation from pressure instrument.
b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
2. Requirements:
a. Materials of construction:
1) Body material: Type 316 stainless steel.
2) O-Ring: Teflon.

D. Level sensor isolation valves:
1. General:
a. Valve shall provide process isolation from level diaphragm.
b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
2. Requirements:
a. Materials of construction:
1) Body material: Type 316 stainless steel.
2) Flange diameter size: 3 inches.

2.03 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

C. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. As specified in Section 17950.

B. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17403

PRESSURE/VACUUM MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum switches.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of contact documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      A. Installation and mounting requirements.
      B. Location within the process.
      C. Accessories: verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Mechanical type pressure switch: One of the following or equal:
   1. Ashcroft B Series Type 400**.**
   2. Or approved equal.

B. Electronic type pressure switch: One of the following or equal:
   1. Ashcroft N Series.
   2. Or approved equal.

2.02 MANUFACTURED UNITS

A. Mechanical type pressure switches:
   1. General:
      a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
   2. Performance requirements:
      a. Pressure range:

1) As specified in instrument list or schedule.

b. Accuracy:
   1) Within 1.0 percent of range.

c. Repeatability:
   1) Within 1.0 percent of range.

3. Element:
   a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
   b. Overpressure:
      1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      2) Minimum 400 percent of nominal range without leakage or rupture.
   c. Sensing element shall not require ambient temperature compensation.
   d. Wetted materials: Stainless steel.
   e. Setpoint:
      1) Dual.
      2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
   f. Adjustable deadband.
   g. Switch elements:
      1) Snap acting.
      2) 2 single pole-double throw (SPDT).

Options	Hermetically Sealed	Maximum Contact Rating @ 120 VAC	Automatic Reset Type	Manual Reset Type	Manufacturer and Model	Rating
Option 1	X	5 A	X		Ashcroft Type 400, B Series	Class I Div 2
Option 2		15 A	X		Ashcroft Type 400, B Series	Unclassified
Option 3	Check with Manufacturer	15 A		X	Ashcroft Type 400, B Series	Check with Manufacturer
Option 4	X	15A	X		Ashcroft Type 700, B Series	Class I Div 1 & 2
Option 5	X	15A		X	Ashcroft Type 700, B Series	Class I Div 1 & 2
Option 6	X	1 A	X		Asco S-Series	See Note 1 (above)
Option 7		15 A	X		Asco S-Series	See Note 1 (above)
Option 8	Check with Manufacturer	Check with Manufacturer		X	Asco S-Series	See Note 1 (above)
Option 9		15 A	X		United Electric Controls Series 400	Unclassified
Option 10		15 A		X	United Electric Controls Series 400	Unclassified

Option 11	X	11 A	X		United Electric Controls Series 120	Class I Div 1 & 2
Option 12	Check with Manufacturer	Check with Manufacturer		X	United Electric Controls Series 120	Class I Div 1 & 2

3) Hermetically sealed.
4) Rated at 5 A, 125/250 VAC.
5) Automatic reset type.

h. Enclosure: Epoxy coated:
1) NEMA Type 4.
2) NEMA Type 4X.
3) NEMA Type 7.

i. Switch mounting:
1) Process connection: 1/2-inch NPT.

4. Components:
a. Provide all necessary hardware for pressure switch mounting.

B. Electronic indicating type pressure switches:
1. General:
a. Pressure switch shall utilize ceramic or polysilicon thin film pressure transducer.
2. Performance requirements:
a. Pressure range:
1) As specified in data sheets
b. Accuracy:
1) Within 1.0 percent of range.
c. Repeatability:
1) Within 1.0 percent of range.
3. Element:
a. Type: Ceramic or polysilicon thin film.
b. Overpressure:
1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
2) Minimum 400 percent of nominal range without leakage or rupture.
c. Sensing element shall not require ambient temperature compensation.
d. Wetted materials: Stainless steel.
4. Transmitter:
a. Setpoint:
1) Single.
2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
b. Adjustable deadband.
c. Switch elements:
1) Snap acting.
2) 2 single pole-double throw (SPDT).
3) [Automatic reset
4) .
d. Enclosure: Epoxy coated
1) NEMA Type 4X**.**
e. Local display:

1) 4-digit LCD or LED.
2) Scaled in engineering units.

f. Switch mounting:
1) Process connection: 1/2-inch NPT.

g. Power supply:
1) 120 VAC.
2) Power consumption: 3 VA maximum.

h. Outputs:
1) Isolated 4 to 20 milliamperes DC with HART communication protocol.

i. Relay outputs:
1) Form C contacts: 2.

j. Rated 5 amps at 120 VAC.

k. Components:
1) Provide all necessary hardware for pressure switch mounting.
2) Provide sun shield for outdoor installations.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
2. Materials: Stainless steel.
3. Mount pulsation dampener or snubber integrally to the pressure switch.
4. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in data sheets or as indicated on the Drawings and as specified in Section 17401:
1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

C. Furnish block and bleed valves as specified in Section 17402.

D. Furnish gauge valves as specified in Section 17402.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. For proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the contract documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17404

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
      d. Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. American Society of Mechanical Engineers (ASME):
   1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure less than 10 pounds per square inch: Model 1188.
      b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
   2. Wika.
   3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
      c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
   3. Element:
      a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon tube.
      b. Socket tips for bellows and Bourdon tube:
         1) Materials: Type 316 stainless steel.
      c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
      d. Wetted materials: Type 316 stainless steel.
   4. Dial gauge:
      a. Dial size: 4-1/2 inches.
      b. Dial case material:
      c. Maximum pressure less than 10 pounds per square inch:
         1) Aluminum.
      d. Maximum pressure greater than or equal to 10 pounds per square inch:
         1) Stainless steel.
      e. Provide safety gauge with safety blow out through the back or top of the unit.
      f. Dial face: Gasketed shatterproof glass or polycarbonate.
      g. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
      h. Provide gauge locks where possible.
      i. Hermetically sealed.
      j. Connection and mounting:
         1) Direct mounted and suitable for outdoor installation.
         2) 1/2 inch NPT.
         3) Connection material: Stainless steel.
      k. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
   1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
   2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
   3. Materials: Type 316 stainless steel.
   4. Mount pulsation dampener or snubber integrally to the pressure gauge.
   5. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401:
   1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide means for gauge isolation as specified in Section 17402:
   1. Mount valve manifold integrally to the gauge.
   2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17405

PRESSURE/VACUUM MEASUREMENT - DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure transmitters and indicators.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.
      e. Section 17950 - Testing, Calibration, and Commissioning.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
   2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
   3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

B. Project environmental conditions as specified in Section 17050.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Shall be the following no equal:
   1. Rosemount: 3051 Series.
   2. Or approved equal.

2.02 MANUFACTURED UNITS

A. Pressure transmitters – direct:
   1. General:
      a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
   2. Performance requirements:
      a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      b. Accuracy:
         1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
         2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
         3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
   3. Element:
      a. Diaphragm type transducer integral to pressure transmitter.
      b. Diaphragm material: Stainless steel or ceramic.
      c. Process material compatibility:
         1) Verify all material compatibilities with the instrument manufacturer.
      d. Process connection: As specified in the Instrument Data Sheets.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - 2 wire loop powered.
         2) Power consumption: 3 VA maximum.
      b. Outputs:
         1) Isolated 4-20mA DC with HART communication protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Local display:
         1) 5-digit LCD.
         2) Scaled in engineering units.
      f. Enclosure:
         1) NEMA Type 4X.
      g. Over range protection: To maximum process line pressure.
      h. Conduit: 1/2 inch male NPT.
   5. Components:
      a. Transmitter mounting:
         1) As specified in the Instrument Data Sheets.
         2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide valve manifolds as specified in Section 17402:
   1. Mount valve manifold integrally to the transmitter.
   2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.
   3. Provide remote or integral diaphragm seals as specified in the Instrument Data Sheets and in Section 17401.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17406

PRESSURE/VACUUM MEASUREMENT - DIFFERENTIAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Differential pressure transmitters and indicators.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
      d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
   2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
   3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than the URV. The calibrated range corresponds to the pressure signal sent from the transmitter.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

C. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of contract documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      A. Installation and mounting requirements.
      B. Location within the process.
      C. Accessories: verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT CONDITIONS

A. Project environmental conditions as specified in Section 17050.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Shall be the following no equal:
   1. Rosemount 3051C Series.
   2. Or approved equal.

2.02 MANUFACTURED UNITS

A. Pressure transmitters - differential:
   1. General:
      a. Differential pressure transmitter assembly shall include a diaphragm-type pressure transducer and microprocessor-based transmitter for measurement of differential pressure.
      b. Differential pressure transmitters shall be used for differential pressure, flow, or liquid level measurement as indicated on the Drawings.
   2. Performance requirements:
      a. As specified in data sheets or instrument index.
      b. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      c. Accuracy:
         1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
         2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
         3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
   3. Element:
      a. Diaphragm-type transducer integral to differential pressure transmitter.
      b. Diaphragm material: Stainless steel or ceramic.
      c. Wetted materials: Stainless steel:
         1) Process material compatibility:
            a) Verify all material compatibilities with the instrument manufacturer.
      d. Diaphragm fill fluid: Silicon Oil.
      e. Process connection: 1/2 inch NPT.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - loop powered.
      b. Outputs:
         1) Isolated 4-20 mA DC with HART communication protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Square root extraction for flow calculation.
      f. Local display:
         1) 5-digit LCD.
         2) Scaled in engineering units.
      g. Enclosure: NEMA Type 4X.
      h. Overrange protection: To maximum process line pressure.

i. Conduit connection: 1/2 inch male NPT.

5. Components:
   a. Transmitter mounting:
      1) As specified in the data sheets or instrument index.
      2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide Blowdown type 5-valve manifold as specified in Section 17402:
   1. Mount valve manifold integrally to the transmitter.
   2. Valve manifold and transmitter shall be assembled by manufacturer and shipped as an assembly.

B. Provide remote diaphragm seals as indicated on the Drawings and as specified in Section 17401.
   1. Diaphragm seal and transmitter shall be assembled by manufacturer and shipped as an assembly.

C. Provide 4 inch Class 150 flanged diaphragm for tank or vessel level measurement:
   1. Flanged diaphragm and transmitter shall be assembled by manufacturer and shipped as an assembly.

D. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Each differential pressure transmitter shall be factory calibrated with 5-point calibration at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 NOT USED

3.03 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. For proper installation of instruments.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17504

ANALYTICAL INSTRUMENT – GAS MONITORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Combustible and toxic gas monitors.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all sections to ensure a complete and coordinated project.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Furnish submittals as specified in Sections 01330 and 17050.

C. Specific definitions:
   1. LEL: Lower Explosive Limit is the lowest concentration of vapor in air, which will burn or explode upon contact with a source of ignition.
   2. Multi-Channel Gas Monitor: A multi-channel gas monitor facilitates monitoring of 2 or more sensor modules.
   3. Sensor Module: A module formed using the combination of a sensor and a transmitter is called a sensor module.
   4. Single-Channel Gas Monitor: A single-channel gas monitor is used to monitor a single type of gas.
   5. STEL: Short Term Exposure Limit is the maximum permissible concentration of a material for duration of 15 minutes.
   6. TWA: Time-Weighted-Average Concentration is the average concentration of a chemical to which it is permissible to expose a worker for a period of 8 hours.
   7. Wet Stack Sensor: A sensor designed for monitoring reactive gas

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following.
   1. Single-Channel Gas Monitor:
      a. MSA: Ultima X Series Single Channel Gas Monitors.
      b. ATI: Series 12 Gas Transmitter.
      c. SMC: Series 4000/5100 Gas Sensor-Transmitter Modules/Single Channel Monitor.

2.02 MANUFACTURED UNITS

A. Single-Channel Gas Monitor:
   1. General:
      a. Single channel gas monitors:
         1) Monitor a single type of gas and produce 4-20mA DC output, which is directly proportional to the gas concentration.
   2. Performance requirements:
      a. Repeatability: ±1 percent of full scale or 2 ppm
      b. Linearity:
         1) Combustibles: ±2 percent of full scale.
         2) Toxic Gas: ±10 percent of full scale or 2 ppm.
         3) Oxygen Deficiency: ±2 percent of full scale.
      c. Range:
         1) Combustible Gas: 0 to 99 percent LEL.

2) Hydrogen Sulfide: 0 to 100 PPM.
3) Oxygen: 0 to 25 percent.

3. Sensor:
   a. Remote mounted.
   b. Gas type:
      1) Combustible Gas.
      2) Hydrogen Sulfide.
      3) Atmospheric Air, to measure oxygen deficiency.
   c. Sensor Type:
      1) Toxic Gas: Electrochemical.
      2) Combustible Gas: Catalytic Bead.
      3) Oxygen Deficiency: Electrochemical.
   d. Corrosion resistant.
   e. Humidity: 15 to 95 percent relative humidity, non-condensing.
   f. Temperature Range:
      1) Operating: -40 degrees Fahrenheit to 131 degrees Fahrenheit.
4. Transmitter:
   a. Wiring Requirements:
      1) Toxic Gas: 3-wire.
      2) Combustible Gas: 3-wire.
   b. LCD or LED Display.
      1) LCD or LED Display shall have an alarm indicator, viewable from 50 feet minimum, with alarm indicator to operate as follows:
         a) Solid Green – normal operation.
         b) Solid Red – fault condition.
         c) Blinking Red – alarm condition.
      2) The alarm values for each sensor shall be as follows:
         a) Hydrogen Sulfide: >1 ppm.
         b) Combustible Gas: 25% LEL.
         c) Oxygen Deficiency: <17%.
   c. Programming and Setup:
      1) Non-Intrusive.
   d. Enclosure:
      1) NEMA 7 Class 1 Division 1 Groups B, C, D.
   e. Power supply:
      1) 24 VDC.
      2) Power consumption: 11 VA maximum.
   f. Outputs:
      1) Isolated 4-20mA DC with HART communication protocol.
      2) Relay outputs:
      3) 3 Form C contact

2.03 ACCESSORIES

A. Calibration Equipment:
   1. Provide calibration kit including appropriate gas with all necessary hardware to calibrate the gas monitoring/indication units for a two-year period.
   2. Furnish carrying case.

B. Sun shield for outdoor Multi-channel Controllers, Sensor Flow Cap and Rainshield.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each gas monitoring system before shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050.

B. Coordinate the installation location for the instrument and verify that the instrument will work properly when installed. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments. Notify the engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.03 ADJUSTING

A. As specified in Section 17050.

B. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.
   2. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.04 CLEANING

A. As specified in Section 17050.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.06 PROTECTION

A. As specified in Section 17050.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17505

ANALYZERS - RESIDUAL CHLORINE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Residual chlorine analyzers.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050.
1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Colorimetric residual analyzers:
1. The following (no equal):
a. HACH CL17.

B. Amperometric residual analyzers **(Not Used)**: delete references to amperometric
1. One of the following or equal:
a. HACH:
1) Chlorine Sensor Model CLT10sc.
2) Transmitter Model sc200.
b. Or approved equal.

2.02 MANUFACTURED UNITS

A. Colorimetric residual analyzers:
1. General:
a. Residual chlorine analyzer utilizing the DPD colorimetric method to provide accurate measurements independent of swings in pH or alkalinity levels in the sample source.
b. Convert from free to total chlorine by changing reagents:

1) Measure a sample blank before each sample measurement to provide zero reference compensation for sample color and turbidity, changes in light intensity due to voltage fluctuations, or light intensity.

2. Performance requirements:
   a. Complete analysis every 2.5 minutes for free or total chlorine residual.
   b. Designed for 30 days of unattended operation, with less than 500 milliliters of reagent used per month.
   c. Accuracy:
      1) Within 5 percent of reading or within 0.035 milligrams per liters .
   d. Range:
      1) 0 to 5 milligrams per liters free or total residual.
   e. Repeatability:
      1) Within 5 percent or 0.005 milligrams per liters.
3. Transmitter:
   a. Microprocessor-based signal converter/transmitter:
      1) Self-diagnostic functions available via the alphanumeric, menu-driven keyboard.
   b. Power supply:
      1) 120 VAC.
      2) Power consumption: 95 VA maximum.
   c. Outputs:
      1) Isolated 4 to 20 milliamperes DC.
      2) Relay outputs:
         a) SPST relay contacts: 2.
         b) Selectable to activate on the following conditions:
            (1) High or low sample concentration.
            (2) Analyzer system warning.
            (3) Analyzer system shutdown.
   d. Enclosure:
      1) ABS plastic with 2 clear polycarbonate windows.
      2) NEMA Type 4X (IP66 rated).
      3) Wall mounted.
   e. Display:
      1) LCD, 3-digit readout, and 6-character alphanumeric scrolling text line.
   f. Light source:
      1) Class 1 LED (light emitting diode), with peak wavelength of 520 nanometer; 50,000 hours estimated minimum life.

B. Amperometric residual analyzers: delete references to amperometric
   1. General:
      a. Residual chlorine analyzer utilizing amperometric technology for continuous monitoring of the free chlorine residual in solution.
   2. Performance requirements:
      a. Continuous on-line analysis for free or total chlorine residual.
      b. Minimum detection: 0.040 milligrams per liters.
      c. Accuracy:
         1) Within 5 percent of reading or within 0.035 milligrams per liters.
      d. Range:
         1) 0 to 5 milligrams per liters free or total residual.
      e. Repeatability:
         1) Within 5 percent or 0.005 milligrams per liters.

3. Components:
    a. Flow through sensors, including flow rate control, multiple probes.
4. Transmitter:
    a. Power supply:
        1) 24 VDC.
        2) Power consumption: 95 VA maximum.
    b. Outputs:
        1) One 4 to 20 milliamperes isolated output with span programmable over any portion of the chlorine residual range.
        2) As indicated in the instrument datasheets.
        3) Relay outputs:
            a) SPST relay contacts: 2.
            b) Selectable to activate on the following conditions:
                (1) High or low sample concentration.
                (2) Analyzer system warning.
                (3) Analyzer system shutdown.
        4) Components:
            a) Manufacturer's cables.
    c. Microprocessor-based signal converter/transmitter.
    d. Display:
        1) LCD, 2-line.
    e. Enclosure:
        1) NEMA Type 4X.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installations.

2.04 SPARE PARTS

A. Provide the following
    1. One complete tubing replacement set
    2. 6 total chlorine reagent sets
    3. 1 free chlorine reagent set
    4. Other wear parts recommended by manufacture to be replaced within 12 months of installation.

2.05 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
    1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 17050.

B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

A. As specified in Section 17950.

3.06 CLEANING

A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.08 PROTECTION

A. As specified in Section 17050.

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17510

INTRUSION - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Magnetic Actuated Intrusion Switch for permanent installations.

B. Related Sections:
   1. Contract Documents are a single integrated document, and as such all DIVISIONs and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all Sections to provide a complete and coordinated project.

C. Furnish all instruments identified on the P&IDs, instrument lists, and instrument data sheets.

1.02 REFERENCES

A. See Section 17050 for a list of references.

1.03 DEFINITIONS

A. Definitions of terms are specified in Section 17050.

1.04 SUBMITTALS

A. Furnish complete submittals in accordance with the listed below:
   1. Product Data on Design Features Including:
      a. Measurement accuracy.
      b. Range and rangeability.
      c. Response time.
      d. Power consumption.
      e. Discrete outputs.
   2. Shop Drawings: Include the following:
      a. Connection diagram.
      b. Installation drawings
      c. Loop diagrams.

B. Manufacturer's Installation Instructions: Include mounting details:
   1. Certified factory calibration data sheets.

C. Furnish complete Product Data, Shop Drawings, Test Reports, Operating Manuals, Record Drawings, Manufacturer’s Field Reports, and other submittals in the format as specified in Section 17050.

1.05 QUALITY ASSURANCE

A. Instruments shall be factory calibrated with certified accuracy traceable to NIST.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

B. Store all instruments in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the manufacturer.

C. Any instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced.

1.07 PROJECT CONDITIONS

A. All instruments must be compatible for the installed site conditions including, but not limited to, material compatibility, site altitude, installed temperature and humidity conditions.

B. Refer to Section 17050 for project environmental conditions.

1.08 WARRANTY

A. Refer to Section 17050.

B. In addition to the requirements of Section 17050, provide manufacturer's warranty for each instrument for a period of one year after project substantial completion.

1.09 MAINTENANCE

A. Provide all parts, materials, fluids, etc. necessary for maintenance and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

B. Provide additional spare parts and spare instruments as specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Magnetic contact switch:
   1. Construction Features:
      a. Case:
         1) Hermetically sealed reed switch with matching actuating magnet.
         2) Anodized aluminum tube housing.
         3) Contact shall be sealed in polyurethane compound.
      b. Mounting: Brackets for both the contact and magnet.
      c. Voltage Rating: 30V DC/AC max.
      d. Current Rating: 0.5A min.
      e. Contact Configuration: SPDT
      f. Make Gap Distance: Up to 3"

g. Cable: Minimum 3” stainless steel armored cable.

2. Product and Manufacturer: Provide one of the following:
   a. Sentrol
   b. GE

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the furnish instruments that are compatible with installed process condition.

B. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

C. Notify the ENGINEER promptly if any installation condition does not meet the instrument manufacturer’s recommendations or Specifications.

3.02 PREPARATION

A. As specified in Section 17050.

3.03 INSTALLATION

A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

A. Site Test and Inspection:
   1. Perform installed tests in accordance with Section 17050.

3.05 ADJUSTING

A. Calibrate all instruments in accordance with the manufacturer’s instructions.

B. Perform any supplemental calibration specified in Section 17050.

3.06 TRAINING

A. As specified in Section 17050.

3.07 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning. The CONTRACTOR shall replace any instruments damaged prior to commissioning:
   1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

3.08 SCHEDULES

A. The CONTRACTOR shall produce completed Instrument Data Sheets for each and every instrument required in DIVISION 17 and for each and every instrument shown on the P&IDs. See Section 17050 for additional requirements. Submit all Instrument Data Sheets for review. Instrument Data Sheets shall be furnished in both hard copy and electronic format.

END OF SECTION

SECTION 17710

CONTROL SYSTEMS - PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
      a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 16075 - Electrical Identification.
      e. Section 16262 - Variable Frequency Drives 0.50-50 Horsepower.
      f. Section 16412 - Low Voltage Molded Case Circuit Breakers.
      g. Section 16422 - Motor Starters.
      h. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Provide all instruments identified in Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1 – Guide on the Surge Environment in Low-Woltage (1000 V and less) AC Power Circuits.

C. Underwriters Laboratories Inc. (UL):
   1. 508C - Standard for Industrial Control Equipment.
   2. 1283 - Standard for Electromagnetic Interference Filters.
   3. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 SYSTEM DESCRIPTION

A. Panel dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
      a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
      b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
      c. Maximum panel depth: 30 inches, unless otherwise indicated.

B. Structural design:
   1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals as specified in Sections 01330 and 17050.

B. Provide a control panel hardware submittal, for each control panel and enclosure being provided on this project, including but not limited to:
   1. Product data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Provide installation details based on calculated shear and tension forces:
         1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
      b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:

1) Weight including panel internal components.
2) Seismic forces and overturning moments.
3) Shear and tension forces in connections.

c. Cooling calculations, to include but not limited to:
1) Highest expected ambient temperature for the enclosure's location
2) Internal heat load.
3) Exposure to direct sunlight.
4) Dimensions of the enclosure in inches.
5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:
1. Seismic panel construction:
a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612:
1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
b. For floor mounted free standing panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
1. Provide all components and equipment with UL 508 listing.
2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE AND HANDLING

A. Project environmental conditions as specified in Section 17050.
1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 EXISTING PRODUCTS

2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA Type 1: Steel.
      b. NEMA Type 4: Steel with gasketed door, rain tight.
      c. NEMA Type 4X: Type 316 stainless steel (unless indicated Type 304 on the drawings)
      d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA Type 12: Steel with gasketed door, dust-tight.
      f. NEMA Type 7: Cast aluminum.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.
   3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. Rittal.
      b. Hoffman Engineering.

c. Saginaw Control & Engineering.

2. Panel assembly:
   a. General guidelines for panel fabrication include:
      1) Continuous welds ground smooth.
      2) Exposed surfaces free of burrs and sharp edges.
      3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2 inch holes at 12 inch spacing to accommodate anchoring of freestanding enclosures to floor.
   b. Construct enclosure and mounting panel using stretcher level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

      1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
   c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
   d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
   e. Door construction:
      1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
      2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.
      3) Heavy gauge piano type continuous stainless steel hinges.
      4) For NEMA Type 12, Type 4 and Type 4X, provide oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
      5) Gasket installed to seal against roll lip on the enclosure opening.
   f. Latches:
      1) For panels each door provided with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, hold doors securely, forming a compressed seal between door and gasket, at the top, side, and bottom.
         a) Provide padlock for each enclosure with padlock provisions.
      2) Include an oil-tight key-locking, 3-point latching mechanism on each door:
         a) Provide 2 keys per panel.
         b) All locks keyed alike.

3) For large type NEMA Type 4 and NEMA Type 4X cabinets, not available with 3-point latching hardware, provide multiple clips and padlock hasps.
4) Provide quick release latches for all NEMA Type 4 and Type 4X enclosures.

g. Panel cut-outs:
1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
3) Reinforce around cut-outs with steel angles or flat bars for the following:
a) Large panel cutouts; for example, openings for local operator interfaces.
b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
a. Minimum 14 gauge, Type 304 stainless steel.
b. Captive stainless steel cover screws threaded into sealed wells.
c. Inside finish: White polyester powder coating.
d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
e. NEMA Type 4X powder coated stainless steel enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.

4. In addition to the requirements specified above the following requirements apply for NEMA Type 4X non-metallic enclosures:
a. Fiberglass construction.
b. 10 gauge plate steel reinforcing on the sides, top, and bottom.
c. All seams sealed.
d. Fiberglass hinges with no exposed metal parts.
e. Captivate stainless steel door screws.
f. Provisions for internal, sidewall, mounting panels either by welded channels to the interior, or by welded collar studs.
g. Provide aluminum mounting panels.
h. Non-metallic enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.

5. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
b. Door hardware: stainless steel.
c. Provide rain canopy and sun shield.
d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.

3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the Engineer.
4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:
   1. Main overcurrent device:
      a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120 VAC circuits:
         1) Door-mounted disconnect handles are not acceptable.
         2) Mechanically interlocked the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
         3) Provide means to defeat the interlock.
         4) Lockable in the off position.
      b. Control panels supplied with 120 VAC:
         1) Provide an internal breaker with the line side terminals covered by a barrier.
         2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
   2. Provide circuit breakers as specified in Section 16412.
   3. Selection and ratings of protective devices:
      a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
      b. Voltage rating: Not less than the voltage of the application.
      c. Select current rating and trip characteristics to be suitable for:
         1) Maximum normal operating current.
         2) Inrush characteristics.
         3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
   4. Provide a separate protective device for each powered electrical device:
      a. An individual circuit breaker for each 120 VAC instrument installed within its respective control panel and clearly identified for function.
      b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
         1) Size external fuse to open before any I/O card mounted fuses.
      c. An individual 5-ampere fuse for each discrete input loop.
      d. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
      e. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
   5. Fuses for 4 to 20 milliamperes signals:
      a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
         1) Label shall not cover or interfere with equipment manufacturer's instructions.

b. Provide fuses rated for the voltage and available short circuit current at which they are applied.
c. Manufacturer: One of the following or equal:
1) Ferraz Shawmut.
2) Littelfuse.
3) Bussmann.

6. Fuse holders:
a. Modular type:
1) DIN rail mounting on 35 millimeters rail.
2) Touch safe design: All connection terminals to be protected against accidental touch.
3) Incorporates blown fuse indicator.
b. Provide nameplate identifying each fuse:
1) As specified in Section 16075.
c. Manufacturer: One of the following or equal:
1) Phoenix Contact.
2) Allen-Bradley 1492-FB Series B.

7. Control circuit breakers:
a. DIN rail mounting on 35 millimeters rail.
b. Manual OPEN-CLOSE toggle switch.
c. Rated 250 VAC.
d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
e. Current ratings: As indicated on the Drawings or as required for the application.
f. Provide nameplate identifying each circuit breaker:
1) As specified in Section 16075.
g. Manufacturer: One of the following or equal:
1) Phoenix Contact.
2) ABB.
3) Allen-Bradley Series.
4) Square D.

D. Conductors and cables:
1. Power and control wiring:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 volts type MTW.
c. Minimum sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.
d. Color:
1) AC power (line and load): BLACK.
2) AC power (neutral): WHITE.
3) AC control: RED.
4) DC power and control (ungrounded): BLUE.
5) DC power and control (grounded): WHITE with BLUE stripe.
6) Ground: GREEN.

2. Signal cables:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 volts, PVC outer jacket.
c. Minimum size: 18 AWG paired triad.

d. Overall aluminum shield (tape).
e. Copper drain wire.
f. Color:
    1) 2 Conductor:
        a) Positive (+): BLACK.
        b) Negative (-): WHITE, RED.
    2) 3 Conductor:
        a) Positive (+): BLACK.
        b) Negative (-): RED.
        c) Signal: WHITE.
g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

E. Conductor identification:
1. Identify each conductors and cables with unique wire numbers as specified in Section 16075.
2. Readily identified without twisting the conductor.

F. General wiring requirements:
1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
5. Provide power surge protection for all control panels.
6. Provide signal surge protection within control panels for each analog I/O, discrete I/O and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
7. Provide nonmetallic ducts for routing and organization of conductors and cables:
    a. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
    b. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
        1) 120 VAC: Grey colored ducts.
        2) 24 VDC: White colored ducts.
8. Cables shall be fastened with cable mounting clamps or with cable ties supported by any of the following methods:
    a. Screw-on cable tie mounts.
    b. Hammer-on cable tie mounting clips.
    c. Fingers of the nonmetallic duct.
9. The free ends of cable ties shall be cut flush after final adjustment and fastening.
10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:

a. Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

13. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050.
2. Air conditioner:
    a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
    b. Provide filters on intake and exhaust openings.
    c. Increase panel sizes as needed to accommodate cooling units.
    d. Enclosure rating: NEMA Type 4X.
    e. Closed loop design.
    f. Power Supply: 120 VAC.
    g. Utilize a CFC-free refrigerant.
    h. Manufacturers: The following or approved equal:
        1) Kooltronic Integrity Series 21.
3. Heating:
    a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters; except, where all of the following conditions apply:
        1) The panel is not supplied with 120 VAC power.
        2) There are no electronics or moisture-sensitive devices in the enclosure.
        3) The panel is smaller than 38 inches high.
4. Heat exchanger:
    a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
    b. Filterless design to facilitate easy cleaning of the core.
    c. Mounting: Indicated on the Drawings.
5. Enclosure temperature sensor as indicated on the Drawings:
    a. Provide wall mount RTD transmitter to measure internal cabinet temperature, in all enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Platinum RTD.
    c. 4 to 20 milliamperes output.
    d. Sensor and electronic enclosure.
    e. Accuracy: Within 2.0 degrees Fahrenheit.
    f. Manufacturer: One of the following or equal:
        1) Omega, EWS series.

2) TCS Basys Controls, TS Series as indicated on the Drawings:

6. Enclosure temperature switch:
   a. Provide wall mount bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
   b. Sensor and electronic enclosure.
   c. Accuracy: Within 2.0 degrees Fahrenheit.
   d. Manufacturer: The following or equal:
      1) Hoffman ATEMNC.
7. Fan ventilation:
   a. Provide Hoffman fan speed control:
      1) Automatically adjust fan speed depending on remote temperature sensor input.
      2) Field adjustable temperature sensitivity.
      3) Polycarbonate control housing.
      4) 120 VAC 60 hertz.
      5) NEMA Type 5-15R cord connections.
      6) Mounting:
         a) Panel mount:
            (1) Mounting brackets.
         b) Rack mount:
            (1) Designed for fan cooling trays.
            (2) 1 RU rack space.
   b. Muffin style:
      1) Provide 2 door/cabinet mounted vent fans for every 72 inches of cabinet width.
      2) Provide Finger Guard kit.
      3) Filter kit with 2 spare filters for each intake fan.
      4) Provide bezel and gasket kit.
      5) Provide fan shroud.
   c. Temperature control switch and alarm:
      1) Power: 120 VAC.
      2) Bimetallic temperature senor.
      3) Adjustable setpoint range 30 degrees Fahrenheit to 140 degree Fahrenheit.
      4) Hoffman ATEM series or equal.
   d. Fan tray:
      1) Provide rack mount fan tray with 6 fans and top mount shroud.

B. Panel meters:
   1. Pointer type:
      a. Suitable for panel mounting.
      b. Minimum scale length: 3-inches.
      c. Calibrated in engineering units.
      d. Accuracy: Within 2 percent of span.
      e. NEMA Type 4/IP65 sealed front metal bezel.
      f. Manufacturer: The following or equal:
         1) Yokogawa.
   2. Digital process indicators:
      a. General:
         1) Integral provisions for scaling.
         2) Scale to process engineering units.

3) Switch programmable decimal points.
4) NEMA Type 4/IP65 sealed front bezel.

b. Current and voltage indicators:
1) 3 1/2 - digit minimum.
2) Minimum character height: 0.5 inches.
3) Accuracy:
a) AC/DC volts: Within (0.1 percent of reading plus 2 digit).
b) DC current: 4 to 20 milliamperes: within (0.1 percent of reading plus 1 digit).
c) DC voltage: 0 to 10 volts: Within (0.1 percent of reading plus 1 digit).

c. Operating voltage: 120 VAC.

d. Operating temperature: 0 degrees Celsius to 60 degrees Celsius.
1) Manufacturer: One of the following or equal:
a) Red Lion.
b) Action Instruments Visipak.

3. Digital bar graph meter:

a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.

b. Suitable for panel mounting.

c. LED display:
1) Not less than 3 decimal digits.
2) Not less than a 101 segment LED bar graph.

d. Input signal:
1) All conventional current loops and voltage control signals.

e. Minimum sample rate of once per second.

f. Provisions for field adjustable scaling and/or offset.

g. Accuracy shall be within 1 least significant digit.

h. Manufacturer: One of the following or equal:
1) Ametek Dixson.
2) Yokogawa.
3) Weschler Instruments.

4. Counters:

a. 6 digits.

b. Switch selectable inputs:
1) Switch contacts.
2) CMOS.
3) TTL.
4) Magnetic pickup.
5) RLC sensors.

c. Selectable up/down control via external signal.

d. Remote reset.

e. Remote inhibit to prevent accumulating counts.

f. Programmable to enable or disable front panel reset.

g. Non-volatile memory to retain all data upon loss of supply power.

h. Sunlight readable.

i. Operating temperature: 0 degrees Celsius to 50 degrees Celsius.

j. Manufacturer: The following or equal:
1) Red Lion PAX Series.

C. Pilot devices:

1. General:

a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
    1) 30.5 millimeters.
c. Heavy duty.
d. Pushbuttons:
    1) Contacts rated:
        a) NEMA Type A600.
    2) Furnish 1 spare normally open and normally closed contact with each switch.
e. Selector switches:
    1) Contacts rated:
        a) NEMA Type A600.
        b) Knob type:
    2) Furnish 1 spare normally open contact and normally closed contact with each switch.
    3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
    1) Type:
        a) LED for interior installations.
    2) Push to test.
    3) Lamp color:
        a) On/Running/Start: Green.
        b) Off/Stop: Red.
        c) Power: White.
        d) Alarm: Amber.
        e) Status or normal condition: White.
        f) Opened: Green.
        g) Closed: Red.
        h) Failure: Amber.

2. Indoor and outdoor areas:
    a. NEMA Type 4/13.
    b. Manufacturer: One of the following or equal:
        1) Allen-Bradley Type 800T.
        2) Square D Class 9001 Type K.
        3) General Electric Type CR104P.
        4) IDEC TWTD.
3. Corrosive areas:
    a. NEMA Type 4X.
    b. Corrosion resistant.
    c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
    d. Manufacturer: One of the following or equal:
        1) Cutler Hammer Type E34.
        2) Square D Class 9001 Type SK.
        3) Allen-Bradley Type 800H.
        4) IDEC TWTD.
4. Hazardous (Classified) Areas/Class I Division 2:
    a. NEMA Type 4X.
    b. Corrosion resistant.

c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc:
    1) All contacts contained within a hermetically sealed chamber:
        a) Pushbuttons.
        b) Selector switches.
        c) Push-to-test contacts on pilot lights.
    2) UL listed and labeled for Class I Division 2 areas.
d. Manufacturer: One of the following or equal:
    1) Cutler Hammer Type E34.
    2) Allen-Bradley Type 800H.

D. Potentiometer and slidewire transmitters:
1. Provide a DC output in proportion to a potentiometer input.
2. Potentiometer input:
    a. 100 ohms to 100 K ohms.
    b. Impedance Greater or equal to 1 M ohms.
    c. Zero turn-up: 80 percent of full scale input.
    d. Span turn-down: 80 percent of full scale input.
3. Field configurable output:
    a. Voltage and current: All conventional current loops and voltage control signals.
4. Accuracy including linearity and hysteresis within 0.1 percent max at 25 degrees Celsius.
5. Operating temperature: 0 degrees Celsius to 55 degrees Celsius.
6. Supply power: 9 to 30 VDC.
7. Manufacturer: The following or equal:
    a. Phoenix Contact.

E. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    a. Minimum isolation level: 1.5 kilovolts AC/50 hertz for at least 1 minute.
    b. Adjustable span and zero.
    c. Accuracy: Within 1.0 percent of span.
    d. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.
2. Manufacturer: One of the following or equal:
    a. Phoenix Contact MCR Series.
    b. Acromag 1500, 600T, 800T, Flat Pack or ACR Series.
    c. Action Instruments Q500 Series or Ultra SlimPakII.
    d. AGM electronics Model TA-4000.

F. Relays:
1. General:
    a. For all types of 120 VAC relays, provide surge protection across the coil of each relay.
    b. For all types of 24 VDC relays, provide a free-wheeling diode across the coil of each relay.
2. General purpose:
    a. Magnetic control relays.
    b. NEMA Type A300 rated:
        1) 300 volts.
        2) 8 Amps continuous (minimum).

3) 7,200 volt-amperes make.
4) 720 volt-amperes break.

c. Plug-in type.
d. LED indication for energization status.
e. Coil voltages: As required for the application.
f. Minimum poles: DPDT.
g. Touch safe design: All connection terminals to be protected against accidental touch.
h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. Provide additional (slave/interposing) relays when the following occurs:
1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
2) Higher contact rating is required in order to interface with starter circuits or other equipment.
l. DIN rail mounting on 35 millimeters rail.
m. Ice cube type relays with retainer clips to secure relay in socket.
n. Integrated label holder for device labeling.
o. Manufacturer: One of the following or equal:
1) Phoenix Contact PLC series.
2) Potter and Brumfield Type KRP or KUP.
3) IDEC R* series. (* = H, J, R, S, U).
4) Allen-Bradley Type 700 H Series.
5) Square D Type K.

3. Latching:
a. Magnetic latching control relays.
b. NEMA Type B300 rated:
1) 300 volts.
2) 10 Amps continuous.
3) 3,600 volt-amperes make.
4) 320 volt-amperes break.
c. Plug-in type.
d. DIN rail mounting on 35 millimeters rail.
e. Coil voltage: As required for the application.
f. Minimum poles: 2PDT; as required for the application. Plus 1 spare pole.
g. Touch safe design: All connection terminals to be protected against accidental touch.
h. Clear cover for visual inspection.
i. Provide retainer clip to secure relay in socket.
j. Manufacturer: One of the following or equal:
1) Square D type 8501 Type K.
2) IDEC TWTD.

4. Time delay:
a. Provide time delay relays to control contact transition time.
b. Contact rating:
1) 240 volts.
2) 10 Amps continuous.
3) 3,600 volt-amperes make.
4) 360 volt-amperes break.
c. Coil voltage: as required for the application.

d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off delay:
    1) For off delay use true power off time delay relays. Where the required timing range exceeds capability of the off delay relay use signal off delay where power loss will not cause undesirable operation or pneumatic time delay relays.
e. Minimum poles: 2PDT.
f. Units include adjustable dial with graduated scale covering the time range in each case.
g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
h. Manufacturer: One of the following or equal:
    1) IDEC RTE series.
    2) Agastat type Series 7000 series (pneumatic).
    3) Allen-Bradley type 700HR Series.

G. Terminal blocks:
1. Din rail mounting on 35 mm rail.
2. Suitable for specified AWG wire.
3. Rated for 15 amperes at 600 volts.
4. Screw terminal type.
5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
6. Finger safe protection for all terminals for conductors.
7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 degree Celsius to 105 degrees Celsius.
8. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine printed terminal identification.
9. Disconnect type field signal conductor terminals with socket/screw for testing.
10. Identify terminals suitable for use with more than 1 conductor.
11. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
12. Provide minimum 25 percent spare terminals.
13. Manufacturer: One of the following or equal:
    a. Phoenix Contact UK5 Series.
    b. Allen-Bradley Series 1492.
14. Wire duct:
    a. Provide flame retardant plastic wiring duct, slotted with dust cover.
    b. Type:
        1) Wide slot.
        2) Narrow slot.
        3) Round hole.
    c. Manufacturer: The following or equal:
        1) Panduit.

H. Surge protection devices:
1. Control panel power:
    a. 120-volt control power source: Non-UPS powered:
        1) Provide surge protection device (SPD) for panel power entrances:
            a) Nominal 120 VAC with a nominal clamping voltage of 200 volts.

b) Non-faulting and non-interrupting design.
c) A response time of not more than 5 nanoseconds.

2) Control panel power system level protection, non-UPS powered:
a) Design to withstand a maximum 10 kA test current of a 8/20 µs waveform according to IEEE C62.41.1Category C Area.
b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.
c) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
d) DIN rail mounting.
e) Attach wiring to the SPD by means of a screw type cable-clamping terminal block:
(1) Gas-tight connections.
(2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
f) Visual status indication of MOV status on the input and output circuits.
g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
h) Meeting the following requirements:
(1) Response time: Less than or equal to 100 ns.
(2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-hertz as determined by a standard 50 ohms insertion test.
(3) Safety approvals:
(a) UL 1283 (EMI/RFI Filter).
(b) UL 1449 2nd Edition.
i) Manufacturer: One of the following or equal:
(1) Phoenix Contact type SFP TVSS/Filter.
(2) Liebert Accuvar series.
(3) Islatrol.

b. 120-volt control power source: UPS powered.
1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
2) Location:
a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
(1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
b) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
3) MCOV: 150 VAC.
4) Surge capability (8/20 microsecond wave): 10 kA.
5) Peak let-through: 620V L-N, 850V L-G.
6) Manufacturer: One of the following or equal:
a) Phoenix Contact Plugtrab PT series
b) MTL Surge Technologies MA15 series

2. Instrument, data and signal line protectors (traditional I/O) – panel mounted:
a. Surge protection minimum requirements: Withstand a 10 kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. DIN rail mounting on 35 millimeters rail (except field mounted SPDs).
c. SPDs consisting of 2 parts:

1) A base terminal block.
2) A plug protection module:
a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
b) Base and plug coded to accept only the correct voltage plug.

d. SPD Manufacturer: One of the following or equal:
1) Phoenix Contact Plugtrab Series.
2) Bournes Series 1800.

3. Instrument, data and signal line protectors (traditional I/O)– field mounted:
a. Surge protection minimum requirements: Withstand a minimum 10 kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. Manufacturer: One of the following or equal:
1) Plugtrab PT Series
2) MTL TP48 Series.

4. Fieldbus network protectors: panel mounted.
a. DeviceNet network surge protectors:
1) Manufacturer: One of the following or equal:
a) Phoenix Contact Trabtech MCR-Plugtrab PT PE/S+1x2-BE header with PT PE/S+1x2-24-ST plug.
b) Transtector Systems Inc. DN-24 series.
2) Nominal operating voltage: 24 VDC.
3) Maximum continuous operating voltage: 35 VDC.
4) Shall withstand a surge current (8/20 micro second combination wave) of 700 amperes.
5) Operating temperature range: -40 to 85 degrees Celsius.
b. Profibus surge protectors:
1) Profibus DP:
a) Manufacturer: The following or equal:
(1) Phoenix Contact PT 1x2+F-BE series base module with PT 3-PB Series protection module.
b) Nominal voltage: 5 VDC.
c) Maximum continuous operating voltage: 5.2 VDC.
d) Nominal current: 450 milliamperes.
e) Nominal discharge surge current: 10 kA.
f) Voltage protection level at 1 kilovolts per micro-second: 55 volts.
g) Shall withstand a maximum discharge surge current (8/20 micro second combination wave) of 10 kA.
h) Operating temperature range: -40 to 85 degrees Celsius.
2) Profibus PA:
a) Manufacturer: One of the following or equal:
(1) Pepperl-Fuchs DP-LBF series base and protection modules.
(2) ABB NGV210 series base module with NGV211 series protection module.
b) Line-line voltage protection level at 1 kilovolts per micro-second: 50 volts.
c) Nominal discharge surge current: 10 kA.
d) Shall withstand a maximum surge current (8/20 micro second combination wave) of 20 kA.
e) Operating temperature range: -40 to 80 degrees Celsius.
c. Foundation Fieldbus H1 surge protectors:

1) Manufacturer: One of the following or equal:
   a) Pepperl-Fuchs DP-LBF series base and protection modules.
   b) ABB NGV210 series base module with NGV211 series protection module.
2) Line-line voltage protection level at 1 kilovolts per micro-second: 50 Volts.
3) Nominal discharge surge current: 10 kA.
4) Shall withstand a maximum surge current (8/20 micro second combination wave) of 20 kA.
5) Operating temperature range: -40 to 80 degrees Celsius.

5. Fieldbus instrument protectors - field mounted.
   a. Profibus PA instruments:
      1) Manufacturers: One of the following or equal:
         a) Pepperl-Fuchs F*-LBF series.
         b) ABB NGV220 Series.
      2) Nominal discharge surge current: 10 kA.
      3) Line-line voltage protection level at 1 kilovolts per micro-second: 50 Volts.
      4) Operating temperature range: -40 to 80 degrees Celsius.
   b. Foundation Fieldbus H1 instruments:
      1) Manufacturers: One of the following or equal:
         a) Pepperl-Fuchs F*-LBF series.
         b) ABB NGV220 Series.
      2) Nominal discharge surge current: 10 kA.
      3) Line-line voltage protection level at 1 kilovolts per micro-second: 50 Volts.
      4) Operating temperature range: -40 to 80 degrees Celsius.

I. Beacons:
   1. Manufacturer: One of the following or equal:
      a. Federal Signal Corp Starfire Series.
      b. Allen-Bradley 855 B *-* 10 Series.
      c. Edwards Model: Model 102.

J. Horns:
   1. Electromechanical:
      a. Manufacturer: One of the following or equal:
         1) Federal Signal 350 or 31X Series.
         2) Edwards: 878EX or 879EX Series.
   2. Electronic:
      a. Manufacturer: One of the following or equal:
         1) Federal Signal 300GCX or 300X Series.
         2) Allen-Bradley 855H or 855XH Series.
         3) Edwards 5530M 5533MD Series.
   3. Rated 80 dB minimum at 10 feet.

K. Power supplies:
   1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
   2. Convert 120 VAC to 24 volt DC or other DC voltages required or as required for the application.

3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
    a. Provide Automatic switchover upon module failure.
    b. Alarm contacts monitored by the PLC.
5. Sized to provide 40 percent excess rated capacity.
6. UL 508C listed to allow full rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output regulation: Within 0.05 percent for a 10 percent line change or a 50 percent load change:
    a. With remote voltage sensing.
10. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
11. Touch safe design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35 millimeters rail.
13. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
14. Manufacturer: One of the following or equal:
    a. Phoenix Contact Quint series.
    b. IDEC PS5R series.
    c. Sola.
    d. Acopian.
    e. PULS.

L. Starters:
1. Magnetic motor starters:
    a. As specified in Section 16422.
2. Integral self-protected starters:
    a. As specified in Section 16422.

M. Variable frequency drives:
1. As specified in Section 16262.

N. Telephone dialers:
1. Plant wide automatic telephone dialers:
    a. Self-contained, microprocessor-controlled system capable of monitoring and controlling up to a minimum of 32 alarm channels.
    b. Input and output channel characteristics selectable from plug-in option cards that include digital and analog inputs, relay output, and printer output capabilities.
    c. Capacity to hold a minimum of 16 phone numbers and capable of dialing a minimum of 9 numbers per channel.
    d. Commence dialing telephone numbers and deliver a voice message upon detection of an alarm or status change from a list associated with the particular alarm condition or combination thereof:
        1) The alarm message to identify and describe current alarm(s) and deliver a digitized human voice, using specific prerecorded message(s) entered by the user.

2) The system redials the telephone numbers in succession until the alarm message receipt is positively acknowledged by one of the following:
a) Depressing selected tone keys on the called telephone.
b) Placing a telephone call back to the system within an adjustable programmed time period.
3) Once acknowledged, the system enters a programmable delay to allow the alarm condition to be addressed before beginning redial.

e. The system receiving incoming telephone calls:
1) Upon receipt of a telephone call, the system reports the alarm status and allows access to the remote operation and programming.

f. FCC and DOC registered for direct connection to the telephone network.
g. Provide a minimum 3-year Manufacturer warranty.
h. Manufacturer: One of the following or equal:
1) Microtel, Model 1000EX Series Automatic Dialer.
2) RACO Verbatim.

2. Unit process automatic telephone dialers:
a. Self-contained, microprocessor-controlled system capable of monitoring and controlling up to 4 alarm channels.
b. Voice recording.
c. Field programmable to dial and re-dial up to 8 pre-determined telephone numbers and deliver a voice message advising the answering party of the fault:
1) Acknowledgment method: tone or callback.

d. FCC and DOC registered for direct connection to the telephone network.
e. Provide a 2-year manufacturer warranty.
f. Manufacturer: One of the following or equal:
1) Microtel Dialstat.
2) RACO Chatterbox.

O. Limit switches:
1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).
9. Manufacturer: One of the following or equal:
a. Allen-Bradley 802.
b. Honeywell HDLS.
c. Omron D4.
d. Eaton E47, E49, E50.
e. ABB equal.

2.07 ACCESSORIES

A. As specified in Section 17050.

B. Provide panels with an inside protective pocket to hold the panel Drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15 inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Provide nameplate to each panel as indicated on the Drawings:
   1. Provide as specified in Section 16075 on all internal and external instruments and devices.
   2. Provide a nameplate with the following markings that is plainly visible after installation:
      a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
      b. Supply voltage, phase, frequency, and full-load current.
      c. Power Source or Circuit ID.
      d. Short-circuit current rating of the panel based on one of the following:
         1) Short-circuit current rating of a listed and labeled assembly.
         2) Short-circuit current rating established utilizing an approved method.
   3. Provide enclosures with a flange mounted disconnect that is interlocked with the doors.

F. Provide a window kit where indicated on the Drawings. The window shall meet the following requirements:
   1. Safety plate glass.
   2. Secured by rubber locking seal.
   3. Allow full viewing of devices issuing visual process data or diagnostics.

G. Lighting:
   1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
      a. Covered or guarded.
      b. Provide On-Off door-activated switches where indicated on the Drawings.
      c. Provide 18-watt fluorescent lamp for indoor enclosures:
         1) Provide additional fixtures for every 36 inches of width.
      d. Provide 40 watt incandescent lamp for exterior enclosures:
         1) Provide additional fixtures for every 36 inches of width.

H. Receptacles:
   1. Provide 1 duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
   2. GFCI, 125-volt, single-phase, 15-amp style plug.
   3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

I. Grounding:
   1. Provide the following:
      a. Grounding strap between enclosure doors and the enclosure.
      b. Equipment grounding conductor terminals.

c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.

2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND” or the letter “G,” or the color green.
3. Signal (24 VDC) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
10. Bond together all control panels both remote and local, processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit to provide a common ground reference.

J. Provide sunshades for outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:
1. Metallic (non-stainless):
a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer’s recommendations to achieve a smooth, well-finished surface.
b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer’s recommended dry film thickness, and allowed to dry before applying the finish coat.
c. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
d. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
a. Stainless enclosures shall be provided with a number 4 brushed finish - not painted.

B. Colors:
1. Exterior color of panels mounted indoors shall be manufacturer’s standard light gray.

2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

2.11 SOURCE QUALITY CONTROL

A. As specified in 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within within 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.

D. Provide 3-1/2 inch high concrete housekeeping pads for free-standing enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor mounted panels.

F. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc. shall be cut in the field, there shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.

H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule, but shall be shown on the Loop Drawings prepared by the Contractor.

I. Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip:

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17712

CONTROL SYSTEMS - UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kilovolt-amperes and below.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
      a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01612 - Seismic Design Criteria.
      c. Section 16050 - Common Work Results for Electrical.
      d. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

A. As specified in Sections 16050 and 17050.

B. American National Standards Institute (ANSI):
   1. ANSI C62.41 (IEEE 587) - Guide for Surge Voltages in Low Voltage AC Power Circuits.

C. Federal Communications Commission (FCC):
   1. FCC Part 15, Class A.
   2. FCC Part 15, Class B.

D. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 519 - Standard Practices and Requirements for Harmonic Control in Electrical Power Systems.
   2. IEEE 1184 - Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems.

E. International Organization for Standardization (ISO):
   1. ISO 9001.

F. National Electrical Manufacturers Association (NEMA):
   1. NEMA PE1 - Uninterruptible Power Systems Specification and Performance Verification.

G. Underwriters Laboratories, Inc. (UL):
   1. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 DEFINITIONS

A. As specified in Sections 16050 and 17050.

B. Specific definitions:
   1. Critical load: Load supplied by the UPS.
   2. MOV: Metal oxide varistor.

1.04 SYSTEM DESCRIPTION

A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified herein and as indicated on the Drawings.

B. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Manufacturer and model number.
   2. Catalog data.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
   4. Ratings:
      a. Input voltage.
      b. Output voltage.
      c. Input/output power factor.
      d. Efficiency.
      e. Harmonic distortion.
      f. Runtime.
   5. Noise specifications.
   6. Heat dissipation.
   7. Warranties and maintenance contracts:
      a. Documentation to demonstrate conformance to specifications noted in this Section.
      b. Descriptive package of offerings of preventative and full service maintenance contracts for both UPS system and batteries.
      c. Extended warranty options available.
   8. All communications requirements such as software, cards, etc.
   9. Alarms and status available for remote monitoring and system health.

C. Shop drawings:
   1. Power distribution block diagrams.
   2. Front and rear views of equipment enclosures:
      a. Front elevation including all control and indicating devices.
   3. Support points and weight of overall equipment.
   4. Schematic and control wiring diagrams including, but not limited to:
      a. Line and load terminals.
      b. Alarm and status terminals.
      c. External wiring requirements for all communication signals.
   5. Switching and overcurrent protective devices.

D. Calculations:
   1. Include derating for temperature and elevation as necessary.
   2. UPS sizing computation:
      a. Apply safety factors as specified in this Section.
      b. Provide itemized list of critical loads, including individual VA and watt ratings.
   3. Battery time calculation based on specified runtime.
   4. Total battery recharge time as a function of capacity utilized.

E. Design data:
   1. Design mounting and anchorage for seismic design criteria specified in Section 01612:
      a. Provide seismic kits as required to meet design criteria.

F. Record documents:
   1. Provide Record Drawings of installed unit(s) including layout and wiring.

G. Manufacturer's field reports.

H. Operation and maintenance manuals:
   1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
   2. Recommendations for maintenance procedures and intervals.
   3. Battery data / replacement information.
   4. Parts list.

1.06 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. A minimum of 10 years experience in the design, manufacture, and testing of solid-state UPS systems.
   2. ISO 9001 certified.

B. Regulatory requirements for complete UPS system:
   1. UL listed per UL Standard 1778
   2. IEEE C62.41, Categories A & B.
   3. FCC 15:
      a. Greater than 2,000 VA - Class A.
      b. Less than 2,000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 ~~SEQUENCING~~ (NOT USED)

1.10 ~~SCHEDULING~~ (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 ~~SYSTEM STARTUP~~ (NOT USED)

1.13 ~~OWNER'S INSTRUCTIONS~~ (NOT USED)

1.14 ~~COMMISSIONING~~ (NOT USED)

1.15 ~~MAINTENANCE~~ (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Double-conversion true-online UPS manufacturers, one of the following :
   1. Free-standing UPS, 700-3,000 VA:
      a. Emerson Network Power - Liebert GXT3 (700 - 3,000 VA).
   2. Rack-mounted UPS, 700-3,000 VA:
      a. Emerson Network Power - Liebert GXT3 (700 - 3,000 VA).
      b. Eaton Corporation - Powerware 9125 RM (700 - 3,000 VA).

2.02 ~~EXISTING PRODUCTS~~ (NOT USED)

2.03 ~~MATERIALS~~ (NOT USED)

2.04 MANUFACTURED UNITS

A. Double conversion true on-line UPS system requirements:
   1. System characteristics:
      a. Provide rack-mount or free-standing UPS as specified and as indicated on the Drawings.
      b. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
      c. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.
      d. Efficiency greater than 85 percent AC-AC, all modes.
      e. Acoustical noise:

1) Less than 55 dBA at 5 feet.

f. Output connections:
   1) Receptacles:
      a) 700-2,500 VA units:
         (1) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
      b) 3,000 VA units:
         (1) Provide a minimum of four NEMA Type 5-20R receptacles.
         (2) Provide at least one NEMA Type L5-30R receptacle.
      c) Greater than 3,000 VA units:
         (1) Provide a minimum of four NEMA Type 5-20R receptacles.
         (2) Provide at least one NEMA Type L14-30R receptacle.
   2) Provide hardwired connections as indicated on the Drawings.

g. Protection:
   1) Undervoltage:
      a) Operate on battery power if incoming source voltage goes below UPS system limits of operation.
   2) Overvoltage:
      a) Operate on battery power if incoming source voltage exceeds UPS system limits of operation.
   3) Overcurrent:
      a) Provide input and output current-limiting protection to ensure adequate overcurrent protection for UPS.
   4) Surge protection:
      a) MOV-based.

2. Electrical characteristics:
   a. AC input:
      1) Single phase.
      2) Voltage as indicated in the UPS schedule.
         a) Fully functional within +10 percent, -15 percent of nominal voltage at full load without depleting battery.
         b) 120 V input:
            (1) 2-wire plus ground.
         c) 208/120 V or 240/120 input:
            (1) 3-wire plus ground.
      3) Current:
         a) Reflected total harmonic distortion (THD) less than 25 percent at rated load.
      4) Frequency range of operation:
         a) 57-63 Hz.
      5) Power factor:
         a) Not less than 0.95 lagging at rated load.
   b. AC output:
      1) Single phase.
      2) Voltage:
         a) Regulation:
            (1) ±3 percent for 3,000 VA rating and below.
            (2) ±5 percent for greater than 3,000 VA rating - static load.
            (3) ±10 percent for greater than 3,000 VA rating - dynamic load.
         b) Total harmonic distortion (THD) when operating on incoming power:

(1) Not more than 3 percent for linear loads with a crest factor of 3:1.
(2) Not more than 5 percent for non-linear loads with a crest factor of 3:1.

c) Transient response:
(1) ±7 percent for a 20-100 percent step load.
(2) Transient recovery time to nominal voltage within 166 milliseconds.

3) Load power factor:
a) UPS shall be capable of supporting the critical loads for all power factors experienced for their full range of operation.

4) Frequency regulation:
a) Within ±3.5 Hz when on utility power.
b) Within ±1.0 Hz when on UPS power.

3. Environmental requirements:
a. Operating ambient temperature:
1) UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
2) Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).

b. Operating altitude:
1) Project site conditions as specified in Sections 16050 and 17050

4. System components:
a. Surge protective devices:
1) MOV-supplied protection.

b. Inverter:
1) Pulse-width modulated AC output signal.
2) Overload withstand minimum time without transferring to bypass:
a) 101 to 110 percent for 2 minutes.
b) 111 to 125 percent for 10 seconds.
c) 126 to 150 percent for 1 second.
d) Greater than 150 percent for 96 milliseconds.
3) Transfer load to bypass when overload capacity is exceeded.

c. Battery rectifier/charger:
1) Recharge batteries to 90 percent in 6 hours or less.

d. Batteries:
1) VRLA (valve regulated lead acid), sealed, maintenance free.
2) Minimum 3-year float service life at 25 degrees Celsius.
3) Integral to UPS enclosure or housed in a matching enclosure.
4) Less than and including 6,000 VA: Hot-swappable.
5) Automatically perform routine battery health monitoring and provide visual, audible, and/or serial warnings if abnormal battery conditions exist.

e. Automatic bypass switch:
1) Integral to UPS system.
2) Sense UPS overload, inverter failure, or overtemperature, and automatically transfer loads to source power.
3) Maximum detect and transfer time of 4-6 milliseconds.
4) Automatic re-transfer without power interruption to critical load.
5) Input shall match output in phase, voltage, frequency, and grounding.
6) Rated to carry the full input current of the UPS.
7) Provide ability for manual operation.

f. UPS chassis:
    1) Electrically isolate from AC output neutral.
    2) Include an equipment ground terminal.
g. Cooling:
    1) Forced air cooled.
h. Locally displayed system indicators:
    1) Audible alarms during abnormal conditions:
        a) UPS fault or overload condition.
        b) Battery on.
        c) Low battery.
        d) Automatic bypass on/off.
        e) Input power on.
        f) Battery testing mode.
i. Controls:
    1) Front-panel pushbuttons:
        a) UPS start-up, shutdown, and manual bypass (for automatic bypass).
        b) Testing.
        c) Visual/audible alarms reset.
    2) Applicable controls as specified in Communications Requirements.
j. Alarm contacts:
    1) Provide relay interface card and required interposing relays for 120 VAC discrete input status signals:
        a) Low battery.
        b) UPS alarm.
        c) On UPS power.
k. Communications requirements:
    1) RS-232.
    2) Ethernet via SNMP - allow remote indication of all alarms and status signals present in the UPS:
        a) Provide manufacturer's software as required.
    3) USB - allow remote indication of all alarms and status signals present in the UPS:
        a) Provide manufacturer's software as required.

2.05 ~~EQUIPMENT~~ (NOT USED)

2.06 ~~COMPONENTS~~ (NOT USED)

2.07 ~~ACCESSORIES~~ (NOT USED)

2.08 ~~MIXES~~ (NOT USED)

2.09 ~~FABRICATION~~ (NOT USED)

2.10 ~~FINISHES~~ (NOT USED)

2.11 ~~SOURCE QUALITY CONTROL~~ (NOT USED)

PART 3 EXECUTION

3.01 ~~EXAMINATION~~ (NOT USED)

3.02 ~~PREPARATION~~ (NOT USED)

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.04 ~~ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION~~ (NOT USED)

3.05 ~~REPAIRS/RESTORATION~~ (NOT USED)

3.06 ~~RE-INSTALLATION~~ (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation as indicated on the Drawings and specified in the Specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.
   6. Inspect batteries for proper polarity.
   7. Check power and control wiring for tightness.
   8. Check terminal connectors for tightness.
   9. Assure connection and voltage of the battery string(s).

3.08 ~~ADJUSTING~~ (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 ~~DEMONSTRATION AND TRAINING~~ (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES

TAG	MINIMUM RUNTIME	INPUT VOLTAGE / CONNECTION	SAFETY FACTOR	NOTES
All PLCs UPS	30 Min	120 VAC/120 VAC		
OPERATOR WORKSTAITON	30 Min	120 VAC/120 VAC		
ENGINEERING WORKSTATION	30 Min	120 VAC/120 VAC		

END OF SECTION

SECTION 17720

CONTROL SYSTEMS – PROGRAMMABLE LOGIC CONTROLLERS HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Programmable logic controller (PLC) based control systems hardware.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17710 - Control System - Panels, Enclosures, and Panel Components.
      d. Section 17733 - Control Systems - Network Materials and Equipment.
      e. Section 17761 - Control Systems - PLC Programming Software.

1.02 REFERENCES

A. As specified in Section 17050.

B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. CPU: Central processing unit.
   2. I/O: Input/Output.

1.04 SYSTEM DESCRIPTION

A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.
      d. Internal processor battery back-up time.
   2. I/O modules:
      a. Type.
      b. Standard wiring diagram.

C. Calculations:
   1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
   2. Submit calculations to verify that spare I/O requirements of this Section are met.
   3. Submit calculations to verify that PLC power supply requirements of this Section are met.

1.06 QUALITY ASSURANCE

A. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

B. Additional requirements:
   1. Provide PLC system components by a single manufacturer:
      a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
   2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
   3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 ~~SEQUENCING~~ (NOT USED)

1.10 ~~SCHEDULING~~ (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 ~~SYSTEM STARTUP~~ (NOT USED)

1.13 ~~OWNER'S INSTRUCTIONS~~ (NOT USED)

1.14 ~~COMMISSIONING~~ (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 17050.

B. In addition to the spare parts requirements specified in Section 17050
   1. I/O cards: 2 spare for each type of I/O card in the system.
   2. Power supplies; 1 spare for every power supply in the system.
   3. Network/communications cards: 1 spare for every network or communications device in the system.
   4. Remote adapter: 1 spare for every remote adaptor in the system.
   5. Chassis: 1 spare for each chassis size in the system.

C. Installed spare requirements:
   1. I/O points:
      a. Provide total of 15 percent spare I/O capacity for each type of I/O signal at every PLC and RIO.
      b. Wire all spare I/O points to field terminal blocks in the PCM.
      c. Space shall be available in each PLC or RIO enclosure to support the future addition of 15 percent additional spare I/O.
   2. PLC backplane capacity:
      a. Provide 15 percent or 2 spare backplane slots, whichever is greater.
   3. PLC memory:
      a. Provide 50 percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers:
   1. Allen-Bradley CompactLogix
   2. No others Allowed

2.02 ~~EXISTING PRODUCTS~~ (NOT USED)

2.03 ~~MATERIALS~~ (NOT USED)

2.04 MANUFACTURED UNITS

A. Programmable logic controller:
   1. Construction:
      a. Furnish plug-in modular system.
      b. Chassis wired logic is not acceptable.
      c. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
         1) Temperature: 0 - 55 degrees Celsius.
         2) RFI: 80 to 1,000 MHz.
         3) Vibration: 10 to 500 Hertz.
         4) Humidity: 0 to 95 percent.

d. Provide internal power supplies designed to protect against over voltage and frequency distortion characteristics frequently encountered with the local power utility.
e. Design the PLC system to function as a stand-alone unit that performs all of the control functions described herein completely independent from the functions of the SCADA system PC-based operator interfaces:
1) Failure of the SCADA system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.

2. Components general:
a. Provide each PLC with the functionality required to implement the control strategies and database shown and specified in the Contract Documents.
b. Furnish each PLC with floating point math and PID controller modulating algorithms.
c. Provide each CPU with internal fault analysis incorporating a fail-safe mode and a dry contact output for remote location alarming, as well as a local indicator on the PLC frame in the event of a fault in the PLC.

3. Central processing unit:
a. Configure each central processor unit so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the specified requirements including the spare and expansion requirements
c. Capable of supporting and implementing closed loop floating-point math and PID control that is directly integrated into the CPU control program.
d. Design the power supply to contain capacitors to provide for orderly shutdown in the event the incoming power does not meet specifications:
1) Cease operation under this condition and force all outputs off.

4. Memory:
a. Non-volatile memory: On-board complementary metal oxide semi-conductor (CMOS), electrically erasable programmable read only memory (EEPROM), PCMCIA, compact flash card, or SD card.
b. Supply with an internal lithium battery to retain non-volatile memory during power outages of up to 30 days.
1) Battery to retain charge for minimum 1 year during normal operations.
2) Furnish with an indicator showing the status of the batteries on the OIS graphic screen to alarm the operator that the batteries should be changed.
c. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
1) This reserve capacity:
a) Totally free from any system use.
2) Programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.

5. Programming:
a. Provide a system where processors are programmed by:
1) Portable laptop computer both locally and via the PLC data network.

6. PLC power supply:
a. Input: 120 VAC.

b. Output current: 5 Amps.
c. Mounted in the PLC housing.
d. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.

7. PLC input/output, I/O modules:
   a. General:
      1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
      2) Provide I/O modules that:
         a) Isolated in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
         b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
         c) Accept dual ended inputs.
      3) The commoning of grounds between I/O points is not acceptable.
      4) Modules that are removable without having to disconnect wiring from the module's terminals:
         a) Utilize a swing-arm or plug-in wiring connector.
      5) Provide at each PLC location the I/O modules required to provide the I/O points, including designated future I/O points, contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies:
         a) Provide at each PLC location an installed spare capacity in accordance with the requirements of this Section.
         b) Wire all spares provided to the field terminal strip.
      6) Condition, filter, and check input signals for instrument limit conditions.
      7) Filter, scale, and linearize the raw signal into an engineering units based measurement.
      8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
      9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
      10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
   b. Discrete input modules:
      1) Defined as contact closure inputs from devices external to the input module.
      2) Provide inputs that are optically isolated from low energy common mode transients to 1,500 volts peak from users wiring or other I/O modules.
      3) Individually isolated inputs.
      4) With LED's to indicate status of each discrete input.
      5) Input signal level: 120 VAC.
      6) Provide input module points that are individually fused with blown fuse indicator lights, mounted external of the module on the output terminal strip:

a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.

c. Discrete output modules:
   1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
      a) Triac outputs may be used, with the permission of the Engineer, care must be used in applying this type of modules to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
   2) Optically isolated from inductively generated, normal mode and low energy, common mode transients to 1,500 volts peak.
   3) LEDs to indicate status of each output point.
   4) Each output point: Individually isolated.

d. Analog input modules:
   1) Signal type: 4 to 20 mA DC.
   2) Analog to digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
   3) The analog to digital conversion updated with each scan of the processor. Individually isolated each input. Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip:
      a) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.

e. Analog output modules:
   1) Signal type: 4 to 20 mA DC.
   2) Individual isolated output points each rated for loads of up to 1,200 ohms.

f. Pre-wired I/O cable system:
   1) Provide the pre-wired I/O cables to eliminate field wiring between the I/O module and field wiring terminal blocks.
   2) The pre-wired I/O cable system consists of the following:
      a) Interface module terminal block assembly:
         (1) Installed on standard DIN rail.
         (2) Provided with terminals for necessary field wiring for 1 I/O module.
         (3) Equipped with a manufacturer standard connector port.
      b) Pre-wired I/O cable:
         (1) Terminate 1 end with manufacturer standard connector to connect to the interface module.
         (2) Pre-wire 1 end to a removable terminal block that plugs into the front of the I/O module.

8. Communications modules:
   a. Remote I/O adapter module:
      1) For any PLC location requiring more than 1 housing to mount all of the I/O modules, or is identified as an RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
      2) Install the RIO adapter module in the PLC backplane and the RIO backplane.

3) Provide adapter modules that supports all available types of I/O modules required.
4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
5) Complete diagnostic LEDs.

b. Network communications modules:
1) General:
a) Install communications modules in the PLC backplane.
2) Ethernet:
a) Ports: RJ-45.
b) Communication rate: 10/100 Mbit/s.
3) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.

9. PLC Housing:
a. Mount the PLC power supply, CPU, rack, and I/O modules in a suitable standard PLC backplane or housing.
b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
c. Provide blank slot filler module for each spare slot.

B. SCADA system interface:
1. As specified in Section 17733.

C. Programming:
1. As specified in Section 17761.

D. Remote inputs and outputs (RIOs):
1. Compatible with all of the PLCs being furnished under this Contract and shall be by the same manufacturer as the PLCs and as a minimum includes:
a. Power supply.
b. Rack.
c. Backplane.
d. Communications module.
e. I/O modules.
f. Enclosure.
2. Provide all cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
3. House the RIO system in enclosures as specified in Section 17710 and consistent with the area classifications as specified in the Electrical Specifications.
4. Power to the RIO modules shall be provided by the enclosure's power supplies, which shall be powered from its associated PCM.
5. The RIO communications modules for each RIO system shall have diagnostic LEDs.
6. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
7. The control system must continue operation should a fault occur on a single RIO drop:
a. Upon clearing the fault, restart communications to that drop automatically.

2.05 ~~EQUIPMENT~~ (NOT USED)

2.06 ~~COMPONENTS~~ (NOT USED)

2.07 ~~ACCESSORIES~~ (NOT USED)

2.08 ~~MIXES~~ (NOT USED)

2.09 ~~FABRICATION~~ (NOT USED)

2.10 ~~FINISHES~~ (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050.

PART 3 EXECUTION

3.01 ~~EXAMINATION~~ (NOT USED)

3.02 ~~PREPARATION~~ (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies:
   1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

3.04 ~~ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION~~ (NOT USED)

3.05 ~~REPAIR/RESTORATION~~ (NOT USED)

3.06 ~~RE-INSTALLATION~~ (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 17050.

3.08 ~~ADJUSTING~~ (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.

C. Perform training by pre-approved and qualified representatives of the ICSC and or manufacturer of the PLC hardware:
   1. A representative of the ICSC may perform the training only if the representative has completed the Manufacturer's training course for the PLC hardware.

3.11 PROTECTION

A. As specified in Section 17050.

3.12 ~~SCHEDULES~~ (NOT USED)

END OF SECTION

SECTION 17733

CONTROL SYSTEMS - NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Materials and equipment used in process control and LAN networks including:
      a. Network Hubs.
      b. Network switches.
      c. Media converters.
      d. Routers.
      e. Patch panels and other data network hardware.
      f. Related accessories.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16075 – Electrical Identification.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17950 - Testing, Calibration, and Commissioning.

1.02 REFERENCES

A. As specified in Section 17050.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 802.3 - Ethernet.
   2. 802.11 - Wireless LANs.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

A. Provide all network equipment identified in the Contract Documents.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Product data:
   1. Include information on all test equipment.
   2. Manufacturer’s operation and installation instructions.

C. Shop drawings:
   1. Complete set of drawings including but not limited to:
      a. System block diagram showing relationship and connections between devices provided under this Contract and existing equipment. Include manufacturer and model information, and address settings.
      b. Network riser diagram.
      c. Network port diagram, which physically locates all, ports within the facility, and identifies their patch panel and switch port.
      d. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates
      e. Electrical connection diagrams.
      f. Complete grounding requirements.
   2. Furnish data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer's model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Test reports:
   1. As specified in Section 17950 and noted in this Section.
   2. Signed test results as described in Part 3 of this Section.
   3. Test results shall include:
      a. Narrative describing the test procedures followed.
      b. Block diagram of test set up.
      c. Manufacturer’s information on test equipment used.
      d. Detailed test results.
      e. A narrative summarizing the results of the testing and identifying any further action required.

E. Operating manuals:
   1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050.

F. Record drawings:
   1. As specified in Section 17050.
   2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 ~~SEQUENCING~~ (NOT USED)

1.10 ~~SCHEDULING~~ (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 ~~SYSTEM STARTUP~~ (NOT USED)

1.13 ~~OWNER'S INSTRUCTIONS~~ (NOT USED)

1.14 ~~COMMISSIONING~~ (NOT USED)

1.15 ~~MAINTENANCE~~ (NOT USED)

PART 2 PRODUCTS

2.01 ~~MANUFACTURERS~~ (NOT USED)

2.02 ~~EXISTING PRODUCTS~~ (NOT USED)

2.03 ~~MATERIALS~~ (NOT USED)

2.04 MANUFACTURED UNITS

1. Unmanaged Ethernet switches:
   a. Manufacturers: One of the following or equal:
      1) Hirschmann SPIDER Series.
      2) Ntron equivalent.
2. Provide 8 port Ethernet hub with the following features:
   a. Ports: 10 Mb, 100 Mb; Auto sensing.
   b. Standards: 10BaseT and 100BaseTX.
   c. Connections: RJ-45.
   d. Power: 100 VAC, 60 Hertz.
   e. Mounting:
      1) DIN rail, unless otherwise indicated on the Drawings.
      2) Provide mounting hardware.
   f. Diagnostics: Power, Link Receive, and Collision LEDs.

   g. Power supply:

a) 24 VDC VAC, 200 Watts/per power supply.

h. Performance:
   1) 10/100M, Full/half-Duplex.
   2) MDI/MDI-X Auto-sensing.

i. Environment:
   1) Operating Temperature Range: 32 to 131 Degrees Fahrenheit.
   2) Humidity: 15 to 95 percent, non-condensing.

j. The Ethernet switch shall be capable of performing basic switching without special programming or configurations. Additional features available through software setup shall include:
   1) Port Security.
   2) Store and Forward.
   3) 10/100 BaseTX.
   4) As required to provide the number of connections required plus 10 percent spare of each type used.

k. Connector type:
   1) Copper: RJ-45.

l. Mounting:
   1) Din Rail.

2.05 ~~EQUIPMENT~~ (NOT USED)

2.06 ~~COMPONENTS~~ (NOT USED)

2.07 ACCESSORIES

A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.

2.08 ~~MIXES~~ (NOT USED)

2.09 ~~FABRICATION~~ (NOT USED)

2.10 ~~FINISHES~~ (NOT USED)

2.11 ~~SOURCE QUALITY CONTROL~~ (NOT USED)

PART 3 EXECUTION

3.01 ~~EXAMINATION~~ (NOT USED)

3.02 ~~PREPARATION~~ (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
   1. Cables shall be installed avoiding sharp bends.
   2. Install cable using lubricant designed for cable pulling.

3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
4. Install LAN cables without splices.
5. Installed bend radii shall not exceed 4 times the cable diameter.
6. Terminated all pairs at the jack and the patch panel.

C. Install cables a minimum of 40 inches away from electrical motors and transformers.

D. Install cables a minimum of 12 inches away from fluorescent lighting.

E. Individual pairs will be untwisted less than 1/2 inch at termination points.

F. All cables and terminations shall be labeled with cable designations as specified in Section 16075.

G. Each data port shall be individually labeled with its patch panel/switch port ID:
1. Labeling must be printed - no handwritten labels will be allowed.

H. At the completion of the wiring installation, provide the following documentation:
1. A plan-view of the premise(s) showing the jack numbering scheme.
2. A printed certification report for the entire wiring installation showing compliance with all EIA/TIA specifications for data cable.
3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.

3.04 ~~ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION~~ (NOT USED)

3.05 ~~REPAIR/RESTORATION~~ (NOT USED)

3.06 ~~RE-INSTALLATION~~ (NOT USED)

3.07 ~~FIELD QUALITY CONTROL~~ (NOT USED)

3.08 ADJUSTING

A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.

C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

3.11 ~~PROTECTION~~ (NOT USED)

3.12 ~~SCHEDULES~~ (NOT USED)

END OF SECTION

SECTION 17750

CONTROL SYSTEMS - WIRELESS COMMUNICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Radio communication system.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 16050
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Subcontract the services of a radio survey company to perform an in-field radio frequency survey.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. CPM: Critical path method.
   2. EIRP: Effective isotropically radiated power.
   3. Fade margin: This is the amount of margin left to allow for the natural variations in radio performance, which will occur due to weather, air density, etc.
   4. FCC: Federal Communications Commission.
   5. ITS: Institute for Telecommunications Science.
   6. RF: Radio frequency.
   7. SIM: Subscriber identity module.

1.04 SYSTEM DESCRIPTION

A. The SWTP radio communication system will serve the following sites:

1. A remote site to existing radio system.

B. Performance requirements:
   1. The following are the radio path requirements for the in-field radio frequency survey:
      a. Minimum fade margin: 15 dB.
      b. No obstructions within the first 1/2 Fresnel Zone.
   2. Operational mode of the radio system:
      a. Bidirectional:
         1) With serial interface and Ethernet.
   3. Radio communication system shall utilize license-free RF technology.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Prepare and submit an agenda for 3 mandatory coordination meetings.
   1. First meeting held within 30 days of the contract award:
      a. The purpose of the meeting is:
         1) For the Contractor to summarize their understanding of the Project.
         2) Discuss any proposed alternatives.
         3) Schedule access to Owner sites.
         4) Schedule the remaining 2 coordination meetings.
         5) Request any additional information required from the Owner.
   2. Second meeting held before performing the RF site survey.
      a. The purpose of the meeting is:
         1) To review the preliminary design and plan the site surveys.
         2) Select the hardware to be used during the on-site RF measurements.
   3. Third meeting held after the final RF survey report has been completed:
      a. The purpose of this meeting is:
         1) For the Contractor to present the findings of the RF survey to the Owner.
         2) To discuss the content of the report in a line-by-line manner.
         3) Outline the recommended and optimal configuration for the Owner's telemetry system architecture.

C. Submittal for telemetry system in-field radio frequency survey:
   1. Initial submittal:
      a. This has to be submitted and approved before the first coordination meeting. Submit the following for review and approval:
         1) Credentials of the firm subcontracted to perform the radio survey.
         2) Project CPM schedule.
         3) Submit a description of testing methods.
         4) Example data forms to be used during the site testing.
   2. Preliminary design submittal:
      a. For all the sites, prepare an RF path report as described below:
         1) Provide a topographic overview of the paths analyzed as part of the radio path study:
            a) Include on the overview:
               (1) Locations of all airports and airstrips located within 2,000 meters of any proposed radio site.

(2) Provide topographical plan and profile drawings for each path.

2) Provide RF path calculations including the following information:
   a) Coordinates of each site in longitude and latitude.
   b) Distance between sites.
   c) Elevation of each site.
   d) Direction of path (degrees from north).
   e) Calculated up tilt/down tilt angles for proposed antenna mountings.
   f) Calculated free space losses.
   g) Estimated received signal: (Max EIRP in dBm - Free Space Losses - Coaxial Cable Transmission Loss +[6] dB for the Receive Antenna Gain).
   h) Calculated fade margin: (Signal Strength).
3) Provide a computerized path analysis study for each path in the radio system. Computer software used in the study shall be based on the ITS Irregular Terrain Model and approved by the Engineer. The calculations shall be performed using the proposed antenna mounting sites and submitted radio system equipment.
4) Provide an intermodulation study for each site at the frequencies proposed and all nearby RF sources.
5) Proposed repeater sites, antenna height mounting adjustments, or other modifications for extending all paths with insufficient fade margin for reliable operation:
   a) Provide path calculations for the revised radio paths.
6) Provide a summary of findings and recommendations for further work.

b. Submit the initial report before the second meeting described in the Submittals article under “Prepare and Submit an Agenda for 3 Mandatory Coordination Meetings.”
c. Update the initial report subsequent to on-site investigations and final design recommendations.

3. Path verification submittal:
   a. Upon completion of the RF survey, submit a final report to the Owner for review a minimum of 30 days before the third coordination meeting as specified in the Submittals article under “Prepare and Submit an Agenda for 3 Mandatory Coordination Meetings.” Summarize the RF survey results and include the following:
      1) Field data captured.
      2) Recommended antenna and repeater/receiver sites.
      3) Recommended antenna heights and types.
      4) Summary of findings and recommendations.
   b. If upon review of the RF Survey report the Owner determines that the information is insufficient or incomplete in any way, perform all necessary actions to complete the report.

D. Submit calculations to verify that mounting will withstand wind-loading criteria:
   1. Antenna mounting structures shall comply with EIA Standard 222.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

B. Procedure for verifying the communications between sites shall be as follows:
   1. Perform radio path calculation study to verify the theoretical performance of the proposed paths.
   2. Field verify the radio paths using field measurement prior to installation.

C. After installation, verify through the use of field collected data, that the installed equipment conforms to reliability benchmark developed as part of the field testing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

~~1.10~~ SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. As specified in Section 17050.

B. Furnish all parts, materials, fluids, etc., necessary for maintenance and calibration purposes for 1 year:
   1. Deliver all supplies before Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Wireless radio communication system to interface into existing system radios:
   1. The following no equal:
      a. Esteem 195Es

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Wireless radio communication system:
   1. License-free frequency hopping spread spectrum radio system:
      a. General:
         1) The license-free radio system comprises the following:
            a) Wireless radio(s).
            b) Antennas.
            c) Surge protectors.
            d) Transmission cables.
            e) Software and other accessories as specified in the Accessories article.
         2) Performance requirements:
            a) Frequency: 900-928 MHz.
            b) Ambient temperature range: -20 to 60 degrees Celsius.
            c) Enclosure protection class: IEC IP20.
      b. Bidirectional (two-way) system:
         1) Wireless radio (transceiver):
            a) Maximum transmission capacity: 1 W.
            b) I/O interface:
               (1) Analog 4 to 20 mA.
               (2) 120 VAC discrete IO.
               (3) Serial communication ports: RS-232.
                  (a) Transmission speed for serial protocol: 1.2 to 38.4 kbps.
               (4) Ethernet RJ-45 port.
                  (a) RF Data Rate: 200 Kbps
            c) Supply voltage: 12 - 30 VDC.
   2. Antennas:
      a. Manufacturers: One of the following, or equal:
         1) Telewave, Inc. ANT Series.
         2) Kathrein Scala.
         3) Andrews.
         4) Microwave Data Systems Clearwave 97-3194A Series.
         5) Phoenix Contact Interface Wireless RAD-ISM Series.
      b. Antenna characteristics:
         1) Yagi antenna:
            a) Frequency range: 902-928 MHz.
            b) Nominal impedance: 50 ohm.
            c) Connector: N-Type.
            d) Gain: As specified in the Examination article
            e) Wind loading: 102.5 mph.
            f) Construction material: All welded aluminum.
            g) Operating temperature:
               (1) Stationary: -40 to 85 degrees Celsius.
               (2) Cyclic: -40 to 55 degrees Celsius.
         2) Omni-directional antenna characteristics:
            a) Frequency range: 902 - 928 MHz.
            b) Nominal impedance: 50 ohm.
            c) Connection: N-type.
            d) Gain: As specified in the Examination article.
            e) Wind loading: 100 mph.

f) Construction material: All welded aluminum.
g) Operating temperature: -40 to 75 degrees Celsius.

c. Mounting accessories:
1) Provide all required mounting accessories required for pole mounting, such as clamps, brackets adapters, and related hardware for a complete installation.
2) Provide mounting hardware to meet the wind and seismic requirements at the Project Site as specified in Section 16050.

d. Antenna structures:
1) Poles:
a) Manufacturer: One of the following, or equal:
(1) Hubbell.
(2) Rudd.
b) Pole shall be 4 inches by 4 inches square aluminum pole with bronze electrocoat finish.
c) Each pole shall be grounded with dedicated ground rod and grounding conductors.
d) Provide required accessories for complete installation of antenna.

3. Surge protector:
a. Manufacturer:One of the following or equal:
1) Andrews:
a) T Series Surge Arrestors.
b) Gas Tube Surge Arrestors.
2) Phoenix Contact Trabtech Series.

4. Transmission cables:
a. Manufacturer: One of the following or equal:
1) Andrews:
a) HELIAX Cable Products.
2) Phoenix Contact Interface Wireless.
b. 1/2-inch, nominal diameter.
c. Continuous section without splices or connectors other than at the radio and antenna.
d. Cable characteristics:
1) Attenuation: Less than 2.2 dB at 960 MHz per 100 feet.
2) Characteristic impedance: 50 ohms.
3) Coaxial shield.
4) Dielectric: Foam.

5. Software:
a. Provide software package for radio diagnostic testing.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. As specified in Section 17050.

B. Radio path survey:
   1. Contractor to conduct a radio path survey for determining feasibility of radio communication in the corresponding sites using licensed or license free radios.
   2. The following are the requirements for each site to perform the radio path survey:
      a. Site co-ordinates: Latitude and longitude.
      b. [Radio:
         1) Manufacturer.
         2) Transmitting power.
         3) EIRP.
         4) Receiver sensitivity.
      c. Antenna:
         1) Manufacturer.
         2) Gain.
         3) Height.
      d. Antenna cable:
         1) Manufacturer.
         2) Transmission line loss.
   3. The survey shall consist of the following activities:
      a. A path study at the sites under consideration.
      b. Survey of geographical and physical relationships of the paths. Obstructions and interference, both physical and electromagnetic, line of sight availability and radio range shall be identified in the survey. Provide digital photographs for each site at each of 8 compass points.
      c. Include bit-error-rate and signal to noise ratios for each site in the final report.
      d. Based on final equipment selection and path recommendations, recalculate the fade margins for the final path design.
      e. Provide an estimate of the probability of the proposed radio path communicating with the master station in terms of a percentage.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING

A. Orient directional antennas as required for maximum receive strength signal intensity (RSSI) during startup.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17761

PLC PROGRAMMING SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Development software to be used with the specified PLC hardware.

B. Related Sections:
   1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all Sections to ensure a complete and coordinated project.
   .

1.02 DEFINITIONS

A. Specific Definitions:
   1. Development Operating Software: The software provided by the PLC Manufacturer for use in programming the PLC.
   2. Application software: The software that is programmed specifically for the project shall be provided by the Contractor's Programmer.

1.03 FINAL SUBMITTALS

A. Product Data:
   1. Programming languages.
   2. Operating system requirements.

B. Control logic:
   1. Fully annotated copy of programmed PLC logic.
   2. Cross-referenced index of all PLC registers or points.

C. Provide Application Software for the specific project process requirements.

1.04 MAINTENANCE

A. Provide programming support for a period of 1 year from substantial completion.

B. Provide system upgrades and maintenance fixes for a period of 1 year from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The PLC programming software system shall be manufactured by PLC hardware manufacturer.

B. The following no equal:
   1. Rockwell Software RSLogix 5000.

2.02 MANUFACTURED UNITS

A. PLC Programming Software:
   1. Furnish Operating Software capable of monitoring and/or control of the PLCs via the local data network:
      a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
      b. Monitor devices at each drop on the PLC data network for proper communications.
   2. Operating System:
      a. Microsoft Windows 7.
   3. The PLC programming software shall be suitable for the PLCs furnished under Section 17720.
   4. PLC programming software for all programming, monitoring, searching, and editing:
      a. Usable both on-line, while connected to the PLC, and off-line.
      b. The Operating Software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
      c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic, forced elements shall be identifiable by means of color change.
      d. Include a search capability to locate any address or element and its program location.
      e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
   5. The PLC programming software shall support the following programming languages:
      a. Function Block Diagram.
      b. Ladder Diagram.
   6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
      a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line by line basis.
      b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
      c. Use a mnemonic associated with each contact, coil, etc, that describes its function.
      d. Utilize the Tag and Loop identification as contained in the P&IDs:
         1) If additional internal coils, timers, etc. are used for a loop they shall contain the loop number.

e. Provide a cross-reference report of program addresses.

7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
   a. Furnish the operating system software that is the standard uncorrupted product of the PLC Manufacturer with the following minimum functions:
      1) Respond to demands from a program request.
      2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
      3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are assured.
      4) Queuing of requests in order of priority if one or more requested resources are unavailable.
      5) Resolution of contending requests for the same resource in accordance with priority.
      6) Service requests for execution of one program by another.
      7) Transfer data between programs as requested.
      8) Management of all information transfers to and from peripheral devices.
      9) Control and recovery from all program fault conditions.
      10) Diagnose and report real-time hardware device errors.
8. Program Execution:
   a. Application Software - program execution scheduled on a priority basis:
      1) A multilevel priority interrupt structure is required.
      2) Enter into a list of pending programs a program interrupted by a higher priority program:
         a) Resume its execution once it becomes the currently highest priority program.
      3) Schedule periodic programs.
      4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
9. Start -up and Restart:
   a. Provide software that initializes and brings a PLC or any microprocessor based hardware unit from an inactive condition to a state of operational readiness.
   b. Initialization:
      1) Determination of system status before start -up of initializing operating system software and initializing application software.
      2) Loading of all memory resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
10. Shutdown:
    a. Where possible provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
    b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
    c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
    d. Alarm PLC failure at the operator interface level.
11. Diagnostics:

a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
b. Use the manufacturer's standard diagnostic routines as much as possible.
c. Furnish diagnostic software and test programs for each significant component in the control system.
d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.

12. Calendar/Time Program:
    a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system level and application software.
    b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
    c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
    a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms must include alarm checks where appropriate.
    d. Provide, as a minimum, the following types of algorithms:
        1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
        2) A switch algorithm, which reads the current, value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated, two outputs with one input and one output with 2 inputs.
        3) A 3-mode Proportional - Integral - Derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supporting both direct and reverse acting modes.
        4) Lead, lag, dead time, and ratio compensators.
        5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
    a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type, in either case the database for each point must include all specified aspects.
16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:
    a. Analog Input Signal Types:
        1) Provide software at the RTUs and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.

b. Input Accuracy:
    1) Inputs must be read with an accuracy of ±0.05 percent full scale or better.
    2) Data conversion errors must be less than 0.05 percent full scale.
    3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once a minute.
    4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
c. Blocking:
    1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
    2) For any input so blocked, the operator may manually enter a value to be used as the input value.
d. Filtering:
    1) For each analog input provide a first order lag digital filter with an adjustable filter factor.
e. Linearizing:
    1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
f. Calculated Values:
    1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated value, constants, etc.
    2) These values must be handled the same as real inputs in terms of record keeping, alarming, etc.
g. Scaling and Zero Suppression:
    1) Provide a conversion program to convert input values into engineering units in a floating-point format.
h. Alarms:
    1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
    2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
    3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
    4) Report return to normal shall also be reported.
    5) Must be possible to inhibit alarms based on external events, ie. lock-out low pump flow alarm when the pump is off.
i. Averages:
    1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
    2) Continuously compute averages, ie. the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
    3) Update hourly averages each minute or at the polling interval for the selected variable.
    4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
    5) Update monthly averages at least once each day and calculate using the results of the daily averages.

6) At the end of each averaging period, store the average values for the period on the hard disk for historical record keeping and reset the present period average register to the present value of the variable.
7) The active database must include the present period average and previous period average for each variable and averaging period.

j. Totals:
1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
3) Assign a separate factor for each totalizing interval.
4) Variables for which totalization is inappropriate must have scaling factors of zero.
5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record keeping and reset the present period totalization register to zero.
6) The active database must include the present period total and previous period total for each variable and totalizing period.

k. Engineering Units:
1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in GPM, MGD, CFS, and Acre-Feet per day.
3) Pre-program the conversion of the engineering units, and if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, ie. multiplication of the database attributes by a constant.
4) The programming method must be at a level and compatible with the specified training of the operator and the OWNER'S personnel.
5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

l. Control Modules:
1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
3) Provide control algorithms for manual control with output values adjustable by the operator.

m. Analog Outputs:
1) Analog outputs must be maintained as part of the database.
2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

18. Some of the above functions may be better accomplished in the Data Acquisition and Graphic Display Software package; it is the responsibility of the PROGRAMMER to optimize the location of the various functions between all software packages.

B. General Control Functions:
1. Analog Control Functions:

a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR and NXOR functions.
c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.

2. Discrete Control Functions:
   a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays and time base.
3. Software Support:
   a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
   b. Call each function as required by the configured controls to perform the intended function.
4. Control and Status Discrepancies:
   a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
   b. For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator programmable time delay (time disagree), and then generate a discrepancy (fail) alarm shall be generated.
   c. Involuntary change in the device's status must also generate an alarm:
      1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
   d. Each command, status, and alarm must cause the color of the symbol to change.
   e. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
      1) Delay periods for each final control element must be adjustable at the operator interface.
      2) List all time delays in the final documentation.
5. Some of the above functions may be better accomplished in the Data Acquisition and Graphic Display Software package, it is the responsibility of the PROGRAMMER to optimize the location of the various functions between all software packages.

C. Control Configuration:
   1. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, set points and tuning constants, etc.
   2. Provide a mechanism to link separate control functions together into an integrated control strategy.
   3. Provide a mechanism to download operational/control set points developed at operator interface to PLC or RTU for operational implementation.

4. Provide a mechanism to define and implement operational/control set points locally at the PLC or RTU and to upload them to the Operator interface for operational record keeping.
5. Perform control configurations on-line at the operator interface, the PLC or RTU may be taken off-line when being configured or downloaded.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. The control system logic program (Application software) shall reside at the PLC level and will be installed by the PROGRAMMER.

B. Use the Tag and Loop identifications found on the P&IDs for all tags used and/or assigned as part of the Application Software.

C. Program the PLC logic using Function Block Diagram or Ladder Diagram programming language.

3.02 DEMONSTRATION AND TRAINING

A. Provide training for an 8-hour day to the OWNER's staff.

B. Demonstrate program functions to the OWNER's representative.

END OF SECTION

SECTION 17762

CONTROL SYSTEMS - SCADA SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. SCADA system software to be used for application software development and real time operation of the SCADA system.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      c. Section 17100 - Control Strategies.
      d. Section 17761 - Control Systems - PLC Programming Software.
      e. Section 17950 - Testing, Calibration, and Commissioning.

C. General requirements:
   1. Software provided under this Contract represents a complete and operating control software system. Achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.
   2. Use existing Client's SCADA system located at the Water Reclamation Plant's Central Control Station – Citect Version 7.2 with service pack 3.
   3. The standard control software listed in this Section does not represent a comprehensive list of software necessary to implement the functional requirements of the Contract Documents. Provide all necessary supplemental drivers, utility software and application software, as required, to meet the functional requirements of the Contract Documents.
   4. Applications software requirements are described in Section 17100.
   5. All software for proper operation as described in the Contract Documents.
   6. All software provided under this Contract to the Owner.

D. Provide copies of all developed application software on CD, or equivalent media.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

A. SCADA system node descriptors:
   1. SCADA client workstation: Client workstations shall be provided with all graphic display and related software for interacting with the SCADA system data. SCADA client's displays shall operate on data maintained by the SCADA server. Display capabilities shall include, but not be limited to:
      a. Process mimic displays.
      b. Real time and historical trend displays.
      c. Alarm summary and sub-summary displays.
      d. System utilities.
   2. SCADA terminal services client: Provide the SCADA system terminal services client with the required application software required to access and display all graphic displays deployed from the SCADA terminal server.
   3. SCADA development node: Unless otherwise indicated, the development node shall be complete with run time software for fully testing the application programs. Functions required at the development node include:
      a. Adding and editing the SCADA database.
      b. Adding and editing graphic displays.
      c. Adding and modify alarm files.
      d. Adding and modify PLC programs.
      e. Modify programs and scripts executing at any of the workstations.
      f. Set up trends and historical displays.
      g. Edit user authorizations.
      h. Other functions as may be required to modify the SCADA system application software.

B. General:
   1. The Contractor shall provide SCADA application software, as required for a complete and functional SCADA system as indicated on the Drawings and as specified in this Section:
   2. Provide software on the system SCADA nodes:
      a. Operator WorkStation -
      b. Development WorkStation -
   3. System configuration:
   4. Client machines obtain real time data from the I/O servers. The client machines shall monitor the status of the servers and re-establish data connections with a I/O server

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 and 17050.

B. Remote alarm database:
   1. After development of the SCADA system database but before system start-up, provide a list of points configured for alarming and submit to the Owner and the Engineer. The Owner/Engineer will identify critical alarms for use in the extended alarming system (e.g. Win-911 remote alarming system) and provide response descriptions.

C. Alarm descriptions shall be of sufficient detail for an accurate review by the Owner.

D. After all shop drawings submittals required herein have been favorably reviewed by the Engineer, the ICSC shall submit the following items, which must also be favorably reviewed and implemented prior to the start of system testing, the entire control system including all required software packages must be operational prior to the required factory acceptance test:
   1. All operator interface display submittals shall be in full color as they will appear on the display screen:
      a. This submittal shall be prepared after the requisite graphics meetings.
      b. The submittal shall include:
         1) Graphic displays.
         2) Trend displays.
         3) Alpha numeric displays.
         4) Alarm displays.
   2. Each display shall be uniquely titled:
      a. Locations for process data shall be clearly identified either through the use of simulated data or by showing variables on the displays and providing a reference list describing those variables.
      b. All dynamic points shall be identified by tag number as a minimum and their operation shall be described on separate sheets:
         1) Color change.
         2) Symbol change.
      c. Three sets of submittals, with screen prints in color on a white background, are required for review by the Owner and Engineer.
      d. One set will be returned with comments.
   3. All periodic and custom reports for the entire control system:
      a. Locations for process data shall be clearly identified, either through the use of simulated data or by showing variables on the report and providing a reference list describing those variables.
      b. Three sets of reports shall be submitted for review by the Engineer.
      c. One set will be returned with comments.

E. Pre-acceptance test documentation as specified in the Sequencing article of this Section.

F. Operator's reference manual:
   1. The ICSC shall prepare and submit a user reference manual for the operator interface system for use by the operators. This manual shall be bound in a 3-ring binder and meet the following minimum requirements:
      a. An index to the manual.
      b. A list of operator interface:
         1) Display screens.
         2) Trends.
         3) Reports.
         4) With display name and description.
      c. A summary of all possible commands and operator inputs to these screens including setpoints:
         1) All control actions shall be included.
      d. A control system block diagram with names and locations of major components.
      e. Instructions for manually printing screens or reports.

1) Real time.
2) Historical.

f. A summary of security levels and their privileges and limitations.
g. Spaces for operators to make notes.

2. A copy of this manual shall be provided to each operator during training on the operator interface operations:
   a. The training class shall include a review of this manual with the operators in addition to more detailed instruction on the operator interface configuration and its use.

G. Review meeting minutes submittals:
   1. Graphics review meeting:
      a. Minutes of Graphic Review Meeting No. 1.
      b. Minutes of Graphic Review Meeting No. 2.
   2. Report review meeting:
      a. Minutes of Report Review Meeting No. 1.
      b. Minutes of Report Review Meeting No. 2.
   3. Alarm review meeting:
      a. Minutes of Alarm Review Meeting No. 1.
      b. Minutes of Alarm Review Meeting No. 2.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050.

B. The manufacturer must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software:
   1. The presence of a formal quality assurance department is required.

C. Software provided under this Section shall be included in the testing specified in Section 17950.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

A. The following items shall be submitted with the final sets of technical manuals required as specified in the Submittals article of this Section, 15 working days before the pre-commissioning test as specified in Section 17050:
   1. All program manuals supplied by the manufacturers with the standard software packages.
   2. All original program disks supplied by the manufacturers with the standard software packages, including any program revisions or updates issued by the manufacturers during the construction period.
   3. All PLC program and operator interface application program files stored on labeled disks:
      a. The PLC program and operator interface application program file disks shall also be updated as required if any changes or corrections are required in this programming before Project completion.

B. Operator interface graphics generation:
   1. The ICSC through the Contractor shall schedule the operator interface graphics meetings.
   2. Topics shall include graphics for:
      a. HMI graphics.
      b. Data acquisition and graphics display system.
   3. The Owner and Engineer shall attend these meetings.
   4. Graphics Meeting No. 1: Held in conjunction with the Preliminary Meeting as specified in Section 17050:
      a. The ICSC shall chair and develop an agenda 3 weeks in advance of the meeting, which shall address the basic criteria to be adhered to in the configuration and development of graphic displays:
         1) At this meeting, the ICSC shall distribute sample display formats for illustration purposes.
         2) As a minimum, this meeting shall address the following issues:
            a) All in plant and remote site areas and conventions for identifying tag names and descriptors.
            b) Designation of groups within each plant area along with tag names and descriptors.
            c) The assignment of individual control loops and inputs to specific groups.
            d) Organization of the systems universal display hierarchy.
            e) Paging schemes to be used to enable the movement from one display to another.
            f) An itemization of the type of display to be used at each level in the graphic hierarchy, i.e., pre-formatted displays, templates, custom graphics, etc.
            g) Color convention to be employed on all graphics for the annotation of various status information, differentiation between alarms based on alarm priority, background colors, static field colors and dynamic field colors.
            h) The utilization of blinking and conditional text.
            i) Definition of graphic symbolism to be used on the Project. This listing shall include but not be limited to symbols to be used for process instrumentation, process equipment, piping, vessels and valves:
               (1) All symbolism must be specific as opposed to generic in that shapes must define both function and type, i.e., specific symbols for each valve design, each pump design, each type of flowmeter, etc.
               (2) If the ICSC's library of shapes does not adequately describe plant or field conditions, the ICSC shall develop additional shapes to meet the plant or field requirements.
               (3) Shapes and symbols used on the P&IDs shall be used as a guideline.
            j) Definition of all display select commands that enable the operator to move within the display hierarchy.
            k) The utilization of cursor movement commands which enable the operator to move within a display.
            l) Definition of control input commands which enable the operator to interact with face plates control stations and custom graphic displays to implement control functions.

m) Definition of data input commands which enable the operator to enter numeric values into the control system.
n) Definition of the utilization of "poke" points or fields that are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
o) A review of graphic generation procedures.

b. Subsequent to the adjournment of Graphics Meeting No. 1, the ICSC shall prepare and formalize a document titled "Graphics Criteria" which shall contain detailed meeting minutes and a definition of all graphic guidelines to be adhered to:
1) This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criteria.
2) The report shall be submitted within 30 calendar days of the meeting's adjournment.

5. Graphics Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050:
a. Subsequent to the finalization of the overall system-wide graphics criteria, the ICSC shall develop graphic packages for the entire operator interfaces being furnished under this Project.
b. At this meeting the ICSC shall submit 5 copies including:
1) A review of the graphic package developed for the process areas for content and completeness.
2) A review of all data fields that display automatically updated process information.
3) A review of all required input commands associated with the graphic access and control manipulation.
c. Subsequent to the adjournment of Graphics Meeting No. 2, the ICSC shall prepare a formalized submittal of the graphic package for review along with the detailed meeting minutes:
1) The report shall be submitted within 30 calendar days of the meeting adjournment.

6. 10 additional displays shall be configured on-line during the pre-commissioning test period.

C. Report generation:
1. The ICSC through the Contractor shall schedule the report generation meetings.
2. The Owner and Engineer shall attend these meetings.
3. Reports Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050:
a. The ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the configuration and development of the reports:
1) At this meeting, the ICSC shall distribute sample formats for illustration purposes.
2) As a minimum, this meeting shall address the following issues:
a) All in plant and remote site data and conventions for identifying tag names and descriptors.
b) Designation of groups within each plant area along with tag names and descriptors.
c) The assignment of inputs to specific categories.
d) Organization of the systems universal report categories.

e) An itemization of the type of report available.
f) Definition of terms to be used on the reports.
g) Definition of all report commands that enable the operator to move within the report editor.
h) The utilization of cursor movement commands which enable the operator to move within a report.
i) Definition of data input commands which enable the operator to enter numeric values into the system.
j) A review of report generation procedures.

3) Subsequent to the adjournment of the Report Meeting No. 1, the ICSC shall prepare and formalize a document titled "Report Criteria" which shall contain detailed meeting minutes and a definition of all report guidelines to be adhered to:
a) This report shall be supplemented by report examples.
b) The report shall be submitted within 30 calendar days of the meeting's adjournment.

4. Reports Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050:
a. Subsequent to the finalization of the overall report format criteria, the ICSC shall develop report packages for review.
b. At this meeting the ICSC shall submit 5 copies including:
1) A review of the report package developed for the process area(s) for content and completeness.
2) A review of all data fields for process information.
3) A review of all required input commands associated with the report access and control manipulation.
c. Subsequent to the adjournment of Report Meeting No. 2, the ICSC shall prepare a formalized submittal of the report package for review along with the detailed meeting minutes:
1) The report shall be submitted within 30 calendar days of the meetings adjournment.
5. 10 additional reports shall be configured on-line during the pre-commissioning test period.

D. Alarming priority:
1. The ICSC through the Contractor shall schedule the alarming priority meetings.
2. The Owner and Engineer shall attend these meetings.
3. Alarming Priority Meeting No. 1: Held in conjunction with the preliminary meeting as specified in Section 17050:
a. The ICSC shall chair and develop an agenda 3 weeks in advance for a meeting, which shall address the basic criteria to be adhered to in the prioritization of alarms:
1) At this meeting, the ICSC shall distribute a listing of all plant alarms identified by tag names and descriptors.
2) As a minimum, this meeting shall address the following issues:
a) Criteria for prioritizing alarms including alarming priority levels. (i.e. Priority 3 - alarm at SCADA; Priority 2 – alarm at SCADA and autodialer; Priority 1 – alarm at SCADA, autodialer, and plant shutdown.)
b) Alarm display banner basic criteria.

3) Subsequent to the adjournment of the Alarming Priority Meeting No. 1, the ICSC shall prepare and formalize a document titled "Alarm Criteria" which shall contain detailed meeting minutes and a definition of all alarming guidelines to be adhered to:
a) The report shall be submitted within 30 calendar days of the meeting's adjournment.

4. Alarming Priority Meeting No. 2: Held in conjunction with the intermediate review meeting as specified in Section 17050:
   a. Subsequent to the finalization of the overall alarm criteria, the ICSC shall develop an alarming priority spreadsheet that will be populated at this meeting.
   b. At this meeting the ICSC shall provide a spreadsheet including:
      1) A listing of all plant alarms identified by tag names and descriptors.
      2) For each alarm listed include a location to enter the alarm priority assignment.
      3) For each alarm listed include a location to enter specific comments related to that alarm.
   c. Subsequent to the adjournment of Alarming Priority Meeting No. 2, the ICSC shall prepare a formalized submittal of the alarming priority spreadsheet for review along with the detailed meeting minutes:
      1) The spreadsheet and meeting minutes shall be submitted within 30 calendar days of the meetings adjournment.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

A. Provide 1-year extended manufacturer’s warranty as follows:
   1. Dedicated technical support department or handled by programming staff or distributor.
   2. Telephone support available 24 hours per day.
   3. Email and web support addresses.
   4. FTP download area.
   5. Knowledge base.
   6. Bulletin board service.
   7. Field service.

B. Provide warranty on application developed under this Project with the understanding that the Owner will be providing the programming but the installation of the software provided in this specification shall be installed and operational so that the Owner can complete the application programs.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following existing SCADA system:
   1. Citect SCADA V7.20 Service Pack 3

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Unless otherwise indicated, provide all run time and development software licensed for:
      a. Unlimited tags.
      b. Unlimited screens.
      c. No direct limits on the number of connections to a server machine.
      d. Provide the number of client licenses as indicated by the number of machines shown or specified, the addition of a new client shall not require an upgrade to the server license.
   2. Provide application software as required to implement the system architecture and functionality as indicated on the Drawings and as described in the System Description article of this Section.
   3. License/registered any new software in the Owner's name.
   4. Turn all software installed on the workstation, over to the Owner with disks, keys and manuals.
   5. The system software specified as part of this Section support SCADA system functions including, but not limited to:
      a. Human machine interface (HMI) process graphics development and display.
      b. Real time point database development and display.
      c. Historical database generation, collection, and display.
      d. Alarming subsystem.
      e. Trending and report subsystems.
      f. Drivers and interfaces.
   6. PLC programming software is specified in Section 17761.

B. SCADA HMI run time software:
   1. Provide run time application software for all control system workstations provided.

C. SCADA I/O server software:
   1. Provide application software for a full SCADA system node including I/O drivers.
   2. Provide drivers for all control system devices as indicated on the Drawings.
   3. Configure historical data collectors to provide data for the historical database on all I/O servers.

D. Alarm dialer software:
   1. Modify existing alarm application software on the workstation identified as the alarm node.

2. The alarm software shall interface with the SCADA system via the SCADA system client software and provide an interface to the appropriate external alarming system.
3. Existing remote alarm software:
    a. Win911 Event Notification Software by Specter Instruments.
    b. No equal.

E. Miscellaneous software:
1. Provide the following support software for use on the SCADA system computers. Install all software on the appropriate system node. Provide all software CD/DVD media.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Install all required software improvement modules (SIMs). At the completion of the Project, and provide installation disk(s) containing all SIMs used on the Project to the Owner.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. Test all software provided as part of this Section as part of the system tests specified in Section 17950.

B. Provide training for 2 of the Owner's staff in the use of the following software packages:
   1. All SCADA application developed under this Project.
   2. All Alarms developed under this Project.
   3. All PLC application developed under this Project.
   4. All radio setup and I/O communication developed under this Project.

C. The Contractor shall cover the costs of tuition, training materials, and related fees.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17901

SCHEDULES - FIELD INSTRUMENTS

PART 1 GENERAL

1.01 SUMMARY

A. The Schedules Field Instrument is not a take-off list. Refer to Drawings and Specifications for additional information. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the Instrument Index are defined on the Drawings.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 SCHEDULES FIELD INSTRUMENTS

A. Schedules Field Instruments attached.

END OF SECTION

SECTION 17901

SCHEDULES - FIELD INSTRUMENTS

Item	Drawing	TagName	Description	Function	Type	Range	ENG. Units	Location	Spec Section
1	20-N-01	20-LE/LIT-101	Supply Injection Tank Level	Level	Ultrasonic Level	0 - 14	ft	Field	17206
2	20-N-01	20-LSH-101	Supply Injection Tank High Level	Level	Level Floats Switch	TBD	ft	Field	17201
3	20-N-01	20-LSL-101	Supply Injection Tank Low Level	Level	Level Floats Switch	TBD	ft	Field	17201
4	20-N-01	20-PSH-101	Injection Supply Pump 1 High Discharge Pressure	Pressure	Switch	TBD	PSI	Field	17403
5	20-N-01	20-PI-101	Injection Supply Pump 1 Discharge Pressure	Pressure	Gauge	0-100	PSI	Field	17404
6	20-N-01	20-PSH-102	Injection Supply Pump 2 High Discharge Pressure	Pressure	Switch	TBD	PSI	Field	17403
7	20-N-01	20-PIT-102	Injection Supply Pump 2 Discharge Pressure	Pressure	Gauge	0-100	PSI	Field	17404
8	20-N-01	20-dPIT-101	Injection Supply Filter Differential Pressure	Pressure	Pressure dp Transducer	0-100	PSI	Field	17406
9	30-N-01	30-AIT-100	Injection Supply Hydrogen Gas Monitor	Gas	Gas Monitor	TBD	ppm	Field	17504
10	40-N-01	40-LT-101	Well No.1 Level	Level	Level dp Transducer	0-500	ft	Field	17403
11	40-N-01	40-LSL-101	Well No.1 Pre-Lube Tank Low Level	Level	Level Floats Switch	TBD	ft	Field	17201
12	40-N-01	40-PSH-101	Well Pump No. 1 High Pressure	Pressure	Pressure Switch	TBD	PSI	Field	17403
13	40-N-01	40-PIT-101	Well Pump No. 1 Discharge Pressure	Pressure	Direct	0-150	PSI	Field	17405
14	40-N-01	40-PI-101	Injection Supply Pump 1 High Discharge Pressure	Pressure	Gauge	0-100	PSI	Field	17404
15	40-N-01	40-FE/FIT-102	Well No. 1 Injection Flow	Flow	6" Magnetic Tube	TBD	gpm	Field	17302
16	40-N-01	40-FE/FIT-101	Well No. 1 Flush Discharge Flow	Flow	6" Magnetic Tube	TBD	gpm	Field	17302
17	40-N-01	40-AIT-101	Well No. 1 Chlorine Residual Analyzer	CL2 Residual	Analyzer	0-10	ppm	Field	17505
18	50-N-01	50-LT-101	Well No.2 Level	Level	Level dp Transducer	0-500	ft	Field	17403
19	50-N-01	50-LSL-101	Well No.1 Pre-Lube Tank Low Level	Level	Level Floats Switch	TBD	PSI	Field	17201
20	50-N-01	50-PSH-101	Well Pump No. 2 High Pressure	Pressure	Pressure Switch	TBD	PSI	Field	17403
21	50-N-01	50-PIT-101	Well Pump No. 2 Discharge Pressure	Pressure	Direct	0-150	PSI	Field	17405
22	50-N-01	50-PI-101	Injection Supply Pump 2 High Discharge Pressure	Pressure	Gauge	0-100	PSI	Field	17404
23	50-N-01	50-FE/FIT-102	Well No. 2 Injection Flow	Flow	6" Magnetic Tube	TBD	gpm	Field	17302
24	50-N-01	50-FE/FIT-101	Well No. 2 Flush Discharge Flow	Flow	6" Magnetic Tube	TBD	gpm	Field	17302

SECTION 17903

SCHEDULES - I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 I/O LIST

A. I/O list attached.

END OF SECTION

SCHEDULES - IO LIST

Item	Drawing	Description	Source Location	Type	PLC PANEL
1	20-N-01	INJECTION WETWELL SUPPLY LEVEL	20-LIT-101	AI	20-PLC-101
2	20-N-01	INJECTION WETWELL LOW LEVEL	20-LY-101	DI	20-PLC-101
3	20-N-01	INJECTION WETWELL HIGH-HIGH LEVEL	20-LY-101	DI	20-PLC-101
4	20-N-01	INJECTION SUPPLY PUMP No.1 RUNNING (VIA ETHERNET)	20-VFD-101	ETH/IP	20-PLC-101
5	20-N-01	INJECTION SUPPLY PUMP No.1 IN AUTO (VIA ETHERNET)	20-VFD-101	ETH/IP	20-PLC-101
6	20-N-01	INJECTION SUPPLY PUMP No.1 FAULT (VIA ETHERNET)	20-VFD-101	ETH/IP	20-PLC-101
7	20-N-01	INJECTION SUPPLY PUMP No.1 SPEED FEED BACK (VIA ETHERNET)	20-VFD-101	ETH/IP	20-PLC-101
8	20-N-01	INJECTION SUPPLY PUMP No.1 START/STOP CMD (VIA ETHERNET)	20-VFD-101	ETH/IP	20-PLC-101
9	20-N-01	INJECTION SUPPLY PUMP No.1 SPEED CMD (VIA ETHERNET)	20-VFD-101	ETH/IP	20-PLC-101
10	20-N-01	INJECTION SUPPLY PUMP No.1 HIGH DISCHARGE PRESSURE ALARM	20-VFD-101	DI	20-PLC-101
11	20-N-01	INJECTION SUPPLY PUMP No.2 RUNNING (VIA ETHERNET)	20-VFD-102	ETH/IP	20-PLC-101
12	20-N-01	INJECTION SUPPLY PUMP No.2 IN AUTO (VIA ETHERNET)	20-VFD-102	ETH/IP	20-PLC-101
13	20-N-01	INJECTION SUPPLY PUMP No.2 FAULT (VIA ETHERNET)	20-VFD-102	ETH/IP	20-PLC-101
14	20-N-01	INJECTION SUPPLY PUMP No.2 SPEED FEED BACK (VIA ETHERNET)	20-VFD-102	ETH/IP	20-PLC-101
15	20-N-01	INJECTION SUPPLY PUMP No.2 START/STOP CMD (VIA ETHERNET)	20-VFD-102	ETH/IP	20-PLC-101
16	20-N-01	INJECTION SUPPLY PUMP No.2 SPEED CMD (VIA ETHERNET)	20-VFD-102	ETH/IP	20-PLC-101
17	20-N-01	INJECTION SUPPLY PUMP No.2 HIGH DISCHARGE PRESSURE ALARM	20-VFD-102	DI	20-PLC-101
18	20-N-01	INJECTION SUPPLY PUMP STATION FILTER DIFFERENTIAL PRESSURE	20-DPIT-101	AI	20-PLC-101
19	20-N-01	INJECTION SUPPLY PUMP No.3 HIGH DISCHARGE PRESSURE ALARM	20-VFD-103	DI	20-PLC-101
20	20-N-01	INJECTION SUPPLY PUMP No.4 HIGH DISCHARGE PRESSURE ALARM	20-VFD-104	DI	20-PLC-101
22	20-N-01	PLC POWER FAILURE ALARM	20-JA-102	DI	20-PLC-101
23	20-N-01	PLC UPS LOW BATTERY ALARM	20-JA-101	DI	20-PLC-101
24	20-N-01	PLC PANEL HIGH TEMPERATURE ALARM	20-TSH-101	DI	20-PLC-101
25	30-N-01	CHLORINE GENERATOR RUNNING (VIA ETHERNET)	30-LCP-100	ETH/IP	20-PLC-101
26	30-N-01	CHLORINE GENERATOR FAILED (VIA ETHERNET)	30-LCP-100	ETH/IP	20-PLC-101
27	30-N-01	CHLORINE GENERATOR LOW WATER PRESSURE (VIA ETHERNET)	30-LCP-100	ETH/IP	20-PLC-101
28	30-N-01	CHLORINE GENERATOR HIGH TEMP (VIA ETHERNET)	30-LCP-100	ETH/IP	20-PLC-101
29	30-N-01	H2 GAS HIGH ALARM (VIA ETHERNET)	30-LCP-100	ETH/IP	20-PLC-101
30	30-N-01	H2 GAS LEVEL	30-AIT-100	AI	20-PLC-101
31	30-N-01	OXIDANT TANK LEVEL	30-LIT-100	AI	20-PLC-101
32	30-N-01	NaCLO METERING PUMP No.1 FAILURE	30-VFD-101	DI	20-PLC-101
33	30-N-01	NaCLO METERING PUMP No.1 IN REMOTE	30-VFD-101	DI	20-PLC-101
34	30-N-01	NaCLO METERING PUMP No.1 START/STOP COMMAND	30-VFD-101	DO	20-PLC-101
35	30-N-01	NaCLO METERING PUMP No.1 SPEED COMMAND	30-VFD-101	AO	20-PLC-101
36	30-N-01	NaCLO METERING PUMP No.2 FAILURE	30-VFD-102	DI	20-PLC-101

Item	Drawing	Description	Source Location	Type	PLC PANEL
37	30-N-01	NaCLO METERING PUMP No.2 IN REMOTE	30-VFD-102	DI	20-PLC-101
38	30-N-01	NaCLO METERING PUMP No.2 START/STOP COMMAND	30-VFD-102	DO	20-PLC-101
39	30-N-01	NaCLO METERING PUMP No.2 SPEED COMMAND	30-VFD-102	AO	20-PLC-101
1	40-N-01	INJECTION WELL No.1 PRE-LUBE OIL LOW LEVEL	40-LSL-101	DI	40-PLC-101
2	40-N-01	INJECTION WELL No.1 LEVEL	40-LT-101	AI	40-PLC-101
3	40-N-01	INJECTION WELL No.1 PUMP RUNNING	40-SSS-101	DI	40-PLC-101
4	40-N-01	INJECTION WELL No.1 PUMP IN AUTO	40-SSS-101	DI	40-PLC-101
5	40-N-01	INJECTION WELL No.1 PUMP FAULT	40-SSS-101	DI	40-PLC-101
6	40-N-01	INJECTION WELL No.1 PUMP START/STOP COMMAND	40-SSS-101	DO	40-PLC-101
7	40-N-01	INJECTION WELL No.1 PUMP HIGH DISCHARGE PRESSURE	40-SSS-101	DI	40-PLC-101
8	40-N-01	INJECTION WELL No.1 PUMP DISCHARGE PRESSURE	40-PIT-101	AI	40-PLC-101
9	40-N-01	INJECTION WELL No.1 FLUSH MOV FULL CLOSE	40-MOV-101	DI	40-PLC-101
10	40-N-01	INJECTION WELL No.1 FLUSH MOV FULL OPEN	40-MOV-101	DI	40-PLC-101
11	40-N-01	INJECTION WELL No.1 FLUSH MOV IN REMOTE	40-MOV-101	DI	40-PLC-101
12	40-N-01	INJECTION WELL No.1 FLUSH MOV CLOSE COMMAND	40-MOV-101	DO	40-PLC-101
13	40-N-01	INJECTION WELL No.1 FLUSH MOV OPEN COMMAND	40-MOV-101	DO	40-PLC-101
14	40-N-01	RECHARGE WELL No.1 RECHARGE MOV FULL CLOSE	40-MOV-102	DI	40-PLC-101
15	40-N-01	RECHARGE WELL No.1 RECHARGE MOV FULL OPEN	40-MOV-102	DI	40-PLC-101
16	40-N-01	RECHARGE WELL No.1 RECHARGE MOV IN REMOTE	40-MOV-102	DI	40-PLC-101
17	40-N-01	RECHARGE WELL No.1 RECHARGE MOV CLOSE COMMAND	40-MOV-102	DO	40-PLC-101
18	40-N-01	RECHARGE WELL No.1 RECHARGE MOV OPEN COMMAND	40-MOV-102	DO	40-PLC-101
19	40-N-01	INJECTION WELL No.1 FLUSHING FLOW RATE	40-FIT-101	AI	40-PLC-101
20	40-N-01	INJECTION WELL No.1 RECHARGE FLOW RATE	40-FIT-102	AI	40-PLC-101
21	40-N-01	INJECTION WELL No.1 CHLORINE RESIDUAL	40-AIT-101	AI	40-PLC-101
22	40-N-01	INJECTION WELL No.1 SUMP HIGH LEVEL ALARM	40-LSH-101	DI	40-PLC-101
23	40-N-01	INJECTION WELL No.1 INTRUSION DOORS	40-NS-101	DI	40-PLC-101
24	40-N-01	INJECTION WELL No.1 ENABLE/DISABLE INTRUSION ALARM	40-HS-101	DI	40-PLC-101
25	40-N-01	INJECTION WELL No.1 PLC POWER FAILURE ALARM	40-JA-102	DI	40-PLC-101
26	40-N-01	INJECTION WELL No.1 PLC UPS LOW BATTERY ALARM	40-JA-101	DI	40-PLC-101
27	40-N-01	INJECTION WELL No.1 PLC PANEL HIGH TEMPERATURE ALARM	40-TSH-101	DI	40-PLC-101
1	50-N-01	INJECTION WELL No.2 PRE-LUBE OIL LOW LEVEL	50-LSL-101	DI	50-PLC-101
2	50-N-01	INJECTION WELL No.2 LEVEL	50-LT-101	AI	50-PLC-101
3	50-N-01	INJECTION WELL No.2 PUMP RUNNING	50-SSS-101	DI	50-PLC-101
4	50-N-01	INJECTION WELL No.2 PUMP IN AUTO	50-SSS-101	DI	50-PLC-101
5	50-N-01	INJECTION WELL No.2 PUMP FAULT	50-SSS-101	DI	50-PLC-101
6	50-N-01	INJECTION WELL No.2 PUMP START/STOP COMMAND	50-SSS-101	DO	50-PLC-101
7	50-N-01	INJECTION WELL No.2 PUMP HIGH DISCHARGE PRESSURE	50-SSS-101	DI	50-PLC-101

SCHEDULES - IO LIST

Item	Drawing	Description	Source Location	Type	PLC PANEL
8	50-N-01	INJECTION WELL No.2 PUMP DISCHARGE PRESSURE	50-PIT-101	AI	50-PLC-101
9	50-N-01	INJECTION WELL No.2 FLUSH MOV FULL CLOSE	50-MOV-101	DI	50-PLC-101
10	50-N-01	INJECTION WELL No.2 FLUSH MOV FULL OPEN	50-MOV-101	DI	50-PLC-101
11	50-N-01	INJECTION WELL No.2 FLUSH MOV IN REMOTE	50-MOV-101	DI	50-PLC-101
12	50-N-01	INJECTION WELL No.2 FLUSH MOV CLOSE COMMAND	50-MOV-101	DO	50-PLC-101
13	50-N-01	INJECTION WELL No.2 FLUSH MOV OPEN COMMAND	50-MOV-101	DO	50-PLC-101
14	50-N-01	RECHARGE WELL No.2 RECHARGE MOV FULL CLOSE	50-MOV-102	DI	50-PLC-101
15	50-N-01	RECHARGE WELL No.2 RECHARGE MOV FULL OPEN	50-MOV-102	DI	50-PLC-101
16	50-N-01	RECHARGE WELL No.2 RECHARGE MOV IN REMOTE	50-MOV-102	DI	50-PLC-101
17	50-N-01	RECHARGE WELL No.2 RECHARGE MOV CLOSE COMMAND	50-MOV-102	DO	50-PLC-101
18	50-N-01	RECHARGE WELL No.2 RECHARGE MOV OPEN COMMAND	50-MOV-102	DO	50-PLC-101
19	50-N-01	INJECTION WELL No.2 FLUSH FLOW RATE	50-FIT-101	AI	50-PLC-101
20	50-N-01	INJECTION WELL No.2 RECHARGE FLOW RATE	50-FIT-102	AI	50-PLC-101
21	50-N-01	INJECTION WELL No.2 INTRUSION DOORS	50-NS-101	DI	50-PLC-101
22	50-N-01	INJECTION WELL No.2 ENABLE/DISABLE INTRUSION ALARM	50-HS-101	DI	50-PLC-101
23	50-N-01	INJECTION WELL No.2 PLC POWER FAILURE ALARM	50-JA-102	DI	50-PLC-101
24	50-N-01	INJECTION WELL No.2 PLC UPS LOW BATTERY ALARM	50-JA-101	DI	50-PLC-101
25	50-N-01	INJECTION WELL No.2 PLC PANEL HIGH TEMPERATURE ALARM	50-TSH-101	DI	50-PLC-101

SECTION 17950

TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to all process control and instrumentation systems for the entire Project.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01330 - Submittal Procedures.
      b. Section 01756 - Testing, Training, and Facility Start-Up.
      c. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
      d. Section 17100 - Control Strategies.

1.02 REFERENCES

A. As specified in Section 17050.

1.03 DEFINITIONS

A. As specified in Section 17050.

B. Specific definitions:
   1. PTO: Profibus Trade Organization.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050
   2. For each test described in this Section, and described in other Instrumentation and Control Specifications, prepare and submit complete test plans, test

procedures, test forms, test binders, test reports, and other submittals, as specified below.

3. Submit manufacturer's certifications and manufacturer's field reports where required.
4. Submit test plans, procedures, forms, and binders for approval by the Engineer before scheduling or performing tests.
5. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
6. Additional test form and test procedure requirements are specified with individual test requirements.

C. Overall test plan:
   1. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   2. Describe the test phases as they apply specifically to this Project and each process system.
   3. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
   4. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
   5. Provide examples of proposed forms and checklists.

D. Test procedures:
   1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   2. Provide a statement of test objectives for each test.
   3. Prepare specific procedures for each process system.
   4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
   5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
   6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
   7. Provide the forms and checklists to be used.

E. Test forms:
   1. Provide test and calibration forms and checklists for each of the following:
      a. Calibration.
      b. Factory acceptance tests.
      c. Loop validation tests.
      d. Pre-commissioning test.
      e. Performance test.
   2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.

3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this Project. The Contractor is to develop and submit test forms customized for the Project and meeting all of the specified test and submittal requirements.

F. Testing binders:
1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
2. Fill out in advance headings and all other information known before the test.
3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

G. Factory acceptance test procedure additional minimal requirements:
1. Prepare and submit a factory acceptance test procedure which includes:
a. Control system testing block diagram.
b. Estimated test duration.
c. Details on the simulator construction, components, and operation.

H. Test reports:
1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
2. Include all completed test binders, forms, and checklists.
3. Submission, review, and acceptance of each test report is generally required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test personnel:
1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. As specified in Section 17050.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Factory acceptance test - general:
   1. Before shipment to the Project Site, the complete PCIS system including all operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other SCADA equipment, shall be assembled, connected, and all software loaded for a fully functional factory acceptance test (FAT) of the integrated system.
   2. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   3. Additional factory tests are specified in other sections of the Instrumentation and Control Specifications.
   4. The Contractor's test personnel shall be responsible for performing tests and recording results.
   5. The FAT will be witnessed by the Engineer and/or other representatives of the Owner.
   6. Right of observation: The Owner retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
   7. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittal.

8. Costs for repeating testing: The Contractor shall pay for Engineer's and other Owner's representatives' travel, subsistence, and labor costs for witnessing the repetition of failed tests.
9. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
10. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
11. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the FAT test site, the FAT shall be, at the Engineer's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the Contractor.

B. Testing simulation:
1. The FAT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA system. All inputs and outputs s
2. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
3. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

C. Preliminary factory acceptance test:
1. A complete preliminary factory acceptance test (pre-FAT) shall be conducted utilizing test procedures approved by the Engineer. The pre-FAT test procedure shall be a subset of the full FAT.
2. The purpose of the pre-FAT is to provide assurance to the Engineer that the SCADA system is ready for the full, witnessed factory acceptance test, in terms of both stability and functionality. Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT. The Contractor shall fully test the SCADA system and fix all deficiencies found before the full FAT.
3. The Owner shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
4. The pre-FAT test results submittal shall include a letter, signed by the Contractor's project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT. The submittal shall include completed pre-FAT test forms, signed by the Contractor's staff, and shall be submitted for review before the start of the FAT.

D. Panel inspections:
1. The Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved shop drawings.
2. Provide panel inspection forms as part of the factory acceptance test procedures submittal.
3. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components

layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.

E. I/O test:
   1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
   2. Test methodology:
      a. Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).
      b. Discrete outputs: Issue commands from operator interface screen, verify output card indicator light and measure response at field wiring terminals. Repeat for each operator interface screen.
      c. Analog inputs: Apply appropriate analog input signal at panel terminals , observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.
      d. Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.
   3. Test forms to include, but not be limited to:
      a. PLC and panel number.
      b. I/O type.
      c. I/O tag name.
      d. Panel terminal block numbers.
      e. Rack/slot/number of I/O point.
      f. Check-off for correct response for each I/O point.
      g. Space for comments.
      h. Initials of individual performing test.
      i. Date test was performed.
      j. Witness' signature lines.

F. System configuration test:
   1. Demonstrate and test the setup and configuration of all operator stations, servers, development stations, and peripherals.
   2. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   3. Demonstrate the proper operation of all peripheral hardware.
   4. Demonstrate all general SCADA functions.
   5. Demonstrate proper operation of log-on and other access security functions.
   6. Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
   7. Test automatic fail over of redundant equipment.
   8. Demonstrate the proper operation of the alarm display and acknowledgement functions.
   9. Test forms:
      a. For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
      b. List the specific tests and steps to be conducted.

c. For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
1) Include signature and date lines.

G. Control logic test:
1. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels.
2. Testing requirements:
a. Demonstrate each function described in Section 17100. Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each general control strategy function to each specific control strategy or loop description.
b. Demonstrate the proper operation of the programming and configuration for each control strategy or loop description. Test each strategy or loop description on a sentence by sentence and function by function basis. Loops with similar or identical logic must each be tested individually.
c. Demonstrate the proper operation of all digital communication links and networks. Verify each digital communication I/O point.
d. Failure testing: In addition to demonstrating correct operation of all specified features, special effort shall be made to demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to SCADA hardware), process equipment failure, and high system loading conditions.
3. Test forms:
a. Include the fully revised and approved control strategy for the loop being tested.
b. Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
c. Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
1) Include signature and date lines.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 17050.

B. Installation supervision:
1. Provide as specified in Section 17050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. General:
   1. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
   2. Failure testing:
      a. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
         1) Equipment failure.
         2) Operator error.
         3) Communications sub-system error.
         4) Power failure.
         5) Process equipment failure.
         6) High system loading conditions.
   3. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day. Testing at other times requires approval of the Engineer.

B. Manufacturer services:
   1. Provide as specified in Section 17050.

C. Sequencing:
   1. See additional requirements specified in the Sequencing article of Section 17050

D. Calibration:
   1. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
   2. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
   3. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
   4. Calibration points:
      a. Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
   5. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
   6. Analyzer calibration:
      a. Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
   7. Complete instrument calibration sheets for every field instrument and analyzer.
   8. Calibration tags:
      a. Attach a calibration and testing tag to each instrument, piece of equipment, or system.

b. Sign the tag when calibration is complete.

E. LAN cable post-testing:
1. After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
2. Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as an ASCII-formatted diskette copy of all traces.
3. After installing connectors:
a. Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
b. Submit a signed test report presenting the results of the cable testing.
c. Repair or replace any portions of the system not meeting TIA/EIA standards for a Category 6 installation. Repaired sections shall be retested.
4. Submit 3 copies of all final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.

F. Industrial network testing:
1. Profibus test procedures:
a. Provide qualified personnel and test equipment required to conduct the inspection and test procedures as specified herein.
b. The scope of qualification and testing services is based on the network representation as indicated on the Drawings. The scope of qualification and testing services shall include the following network types:
1) Profibus DP networks.
2) Profibus PA networks.
c. Network qualification and testing activities:
1) Network installation qualification, testing, and documentation:
a) This qualification and testing activity focuses on the physical media and its installation.
b) Conduct a physical inspection to establish the network configuration:
(1) Validate the node type and quantity.
(2) Identify improper installation and damaged components.
(3) Validate integrity of cables and connectors via a physical media test to confirm the signal propagation capabilities of the network media.
(4) Corrective measures shall be recommended based on the results of the inspections and testing.
2) Network operations qualification, testing, and documentation:
a) This qualification and testing activity takes place after the network is commissioned and is under normal operating conditions.
b) The network performance is monitored and measured using non-intrusive test equipment and procedures.
c) The test results are analyzed and corrective measures recommended.
3) Report:

a) Prepare a report that documents the results of the qualification and testing activities.
b) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
c) The report to include, but not limited to, the following:
(1) Executive summary for each network.
(2) Inspection and test results for each network.
(3) Calculated network parameters.
(4) Recommendations.
(5) Description of test procedures and required test equipment.

4) Network agency specifications:
a) The testing and qualifications services will adhere to the recommended standards and practices of the referenced standards bodies and agencies:
(1) Profibus networks.
(2) Profibus network requirements, application specifications, designs, and services shall be in conformance with the applicable PTO specifications.

5) Manufacturer's specifications and guidelines:
a) Include all applicable manufacturer's specifications and guidelines.
b) Manufacturer's specifications and guidelines may supersede the specifications of the applicable governing body for the associated network.

6) Test sequence and responsibilities:
a) All qualification and testing activities will be conducted by the Contractor. Figure 1, Network Test Sequence and Responsibilities, defines the general test sequence:
(1) Before commencing any network inspection or testing activities, verify that all network segments and nodes are in their final installed condition.
(2) The installer to provide all necessary components and labor required to address changes required to bring the network into compliance. The installer shall be available at the time of network inspection and testing to address network deficiencies.
(3) Before commencing any network inspection or testing activities, inspect all network components and all deficiencies addressed.

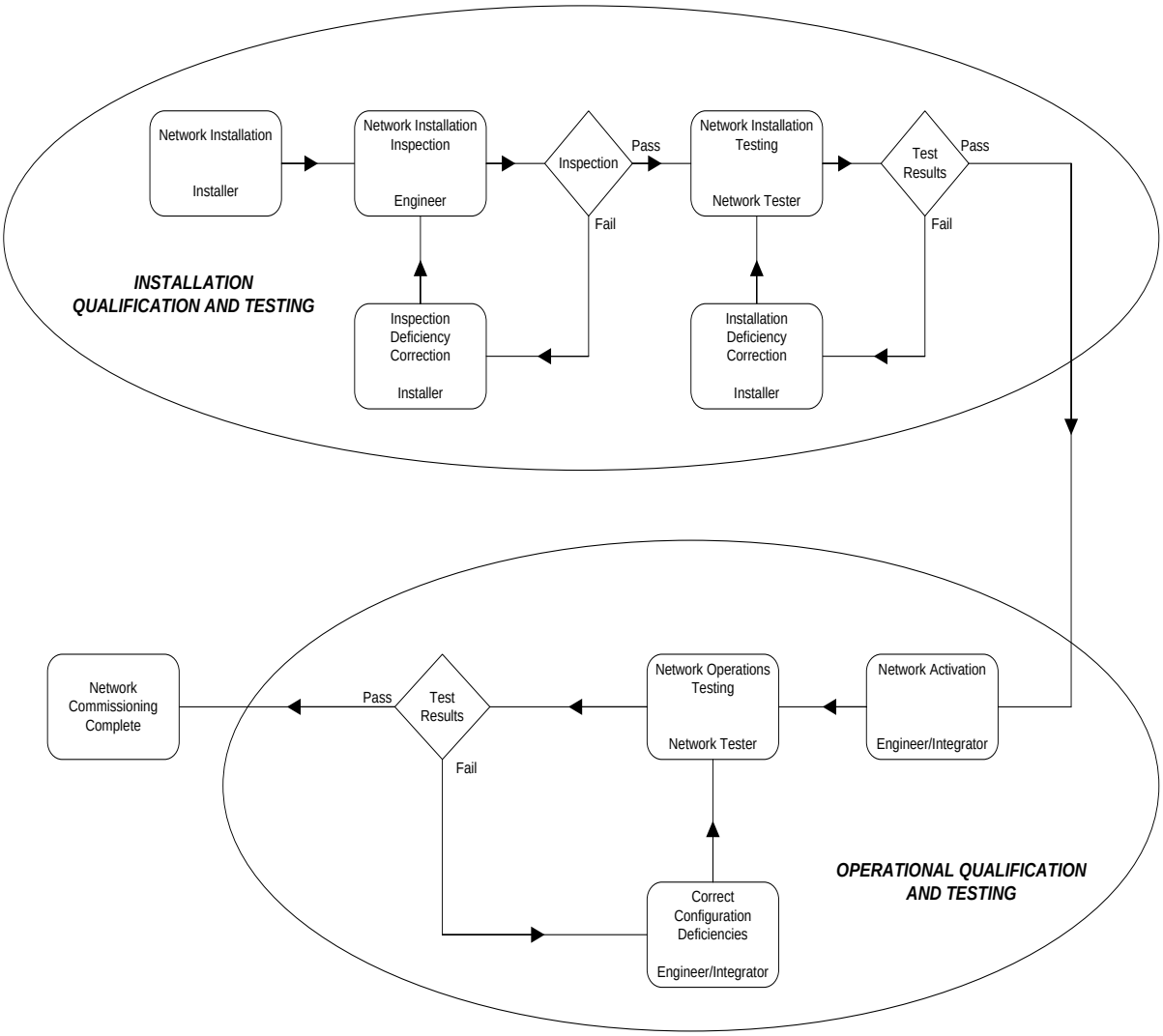


Figure 1
Network Test Sequence and Responsibilities

7) Profibus test procedure:
   a) The following prerequisite conditions must be completed before commencing the qualification and testing activities:
      (1) Installation qualification and testing:
         (a) All cabling installed, terminated, and labeled.
         (b) All network node devices installed.
         (c) All node devices physically disconnected from the network.
      (2) Manufacturer's data and specifications for all installed network components, available on-site for use by the network testing firm.
      (3) A complete set of construction drawings and specifications with all addenda and change orders are available on-site for use by the network testing firm.
8) Operations qualification and testing:

a) Network installation qualification and testing successfully completed.
b) Network is commissioned and is operating under normal conditions.
c) Process and process equipment is not dependent on operation of the network:

2. Network operation may be interrupted for inspection and testing.
3. Test equipment:
   a. The following test equipment will be utilized in the execution of the described qualification and testing procedures.
      1) Network line analyzer, ProfiTrace v1.6.
      2) Oscilloscope, Fluke Scopemeter Series 190 or equivalent.
      3) Digital VOM, Fluke 87 Multimeter or equivalent.
      4) Network bus monitor, ProfiTrace v1.6.
4. Installation qualification and test procedures:
   a. Visual and mechanical inspection:
      1) Compare network devices nameplate data with drawings and specifications.
      2) Confirm network components are PTO compliant.
      3) Verify labeling of all trunk cables.
      4) Confirm minimum cable distance between nodes.
      5) Verify the presence/absence of stub lines.
      6) Verify network terminators are in place.
      7) Verify power supply source and connections for active terminations.
      8) Verify total network node count.
      9) Verify power supply specifications including quantity, ratings, locations, and configuration. Verify power supply source of supply location, conductor size, and rating.
      10) Inspect accessible network cabling for adherence to specified installation practices:
         a) Cable installed in conduit or protective raceway.
         b) Cable proximity to high voltage wiring.
         c) Exposure to extreme temperatures, shock, vibration, chemicals, or moisture.
         d) Bend radius.
      11) Inspect cable and conductor terminations for adherence to specified installation practices.
      12) Check all accessible components for evidence of physical damage.
      13) Check grounding techniques including ground conductor sizes and termination points.
      14) Non-permissible cable length.
      15) Wrong cable type.
      16) Signal reflections.
5. Electrical tests:
   a. Measure network resistance.
   b. Measure network cable length.
   c. Line analysis for the following conditions:
      1) Short circuit between signal lines A and B.
      2) Short circuit between signal lines A and B and the cable shield.
   d. Shield continuity.
   e. Cross-wired signals lines.
   f. Terminator installed in wrong position.

g. Poor transmission or reception levels.
h. Non-permissible stub line.

6. Generate slave list.
7. Measure power supply voltage at active terminations.
8. Evaluation:
   a. Confirm the network cable topology (length and configuration) does not exceed data rate limitations.
   b. Confirm total stub length (if required by design) does not exceed data rate limitations.
   c. Calculate spare trunk length for the specified data rate.
9. Operations qualifications and test procedures:
   a. Electrical tests:
      1) Examine the data traffic between the master and each slave device.
      2) Verify baud rate.
      3) Confirm signal level.
      4) Verify network cycle time.
      5) Generate “live” slave list.
      6) Verify and record scanner diagnostic data including node status and error codes.
      7) Monitor and capture network waveform.
10. Evaluation:
    a. Confirm all specified slave devices appear on the live list.
    b. Evaluate data traffic between master and each slave to confirm proper slave configuration and performance.
    c. Inspect waveform capture for evidence of excessive noise.
    d. Evaluate and report any failed or questionable network tests.
    e. Evaluate and report network error codes and related symptoms.

A. Ultrasonic and radar check out:
   1. Check response under all operating conditions.
   2. Track all responses through trend charts in the SCADA system.
   3. Provide Echo Transmission and signal quality on all level transmitters including guided and unguided units.
      a. Provide printout of the actual transmission and all parameters.

B. Loop check/validation:
   1. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA system. Issue commands from the SCADA system and verify proper responses of field devices. Use actual process inputs wherever available.
   2. Provide “end-to-end” tests:
      a. Test SCADA system inputs from field device to SCADA system operator workstations.
      b. Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
      c. Observe and record responses at all intermediate devices.
      d. Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
      e. For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.

3. Retest any loop following any necessary corrections.
4. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
5. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
6. Apply provisional settings on controllers and alarm set points.
7. Record all analog loop test data on test forms.
8. Exercise each field device requiring an analog command signal, through the SCADA system. Vary, during the validation process, the output from the PLC SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
9. Exercise each field device providing a discrete input to the SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
    a. Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
    b. Exercise starters, relay contacts, switch contacts, and observe proper operation.
    c. Calibrate and test instruments supplying discrete inputs, and observe proper operation.
10. Test each device accepting a discrete output signal from the SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
    a. Stroke valves through outputs from the SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA system.
    b. Exercise motors starters from the SCADA system and verify proper operation through direct field observation.
    c. Exercise solenoids and other field devices from the SCADA system and verify proper operation through direct field observation.
11. Include in the test forms:
    a. Analog input devices:
        1) Calibration range.
        2) Calibration data: Input, output, and error at each test value.
        3) Analog input associated PLC register address.
        4) Value in PLC register at each test point.
        5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
    b. Analog output devices:
        1) Calibration range.
        2) Test value at each test point.
        3) Analog output associated PLC register address.
        4) Control variable value at field device at each test point.
        5) Physical device response at each test point:
            a) Response to be actual valve position, or motor speed, etc.
    c. Discrete instrument input devices:
        1) Switch setting, contact action, and dead band.

2) Valve position switches:
a) Response in the PLC as the valve is stroked from the PLC.
b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
3) Operator interface switches (control stations and other pilot devices) and associated response.
4) Starter and drive auxiliary device contact response.
5) Response of all other discrete inputs to the PLC.

d. Discrete output devices:
1) Observed response of field device to the discrete output from the PLC.
2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

e. Test equipment used and associated serial numbers.

C. Pre-commissioning (functional) test:
1. General:
a. Commence pre-commissioning tests after completion of all loop check/validation tests:
1) As specified in Section 17050, Sequencing and Scheduling article.
b. Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
c. Pre-commissioning testing to generally occur in conjunction with functional testing specified in Section 01756.
d. Additional tests are specified in other Instrumentation and Control Sections.
e. Follow approved detailed test procedures and check lists for all pre-commissioning and test activities.

2. Control logic operational validation:
a. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
b. Demonstrate all control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
c. Test in detail on a function-by-function and sentence-by-sentence basis.
d. Thoroughly test all hardware and software functions:
1) Including all hardwired and software control circuit interlocks and alarms.
e. Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
f. Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the factory acceptance tests, modified and expanded to include all field instruments, control panels, circuits, and equipment.

3. Loop tuning:

a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4 wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
c. If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.

4. Pre-commissioning validation sheets:
   a. Document each pre-commissioning test on an approved test form.
   b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
   c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
      1) Loop number and P&ID number.
      2) Control strategy, or reference to specification tested.
      3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the pre-commissioning test. Otherwise, create new forms.
   d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
      1) Specification page and paragraph of function demonstrated.
      2) Description of function and/or text from specification.
      3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the pre-commissioning test.
5. Pre-commissioning certification:
   a. Document via a certified report the completion of all pre-commissioning and test activities:
      1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all pre-commissioning test requirements have been satisfied.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

A. Performance/reliability/operational tests:

1. After successful completion of the pre-commissioning test as accepted by the Engineer and Owner, the performance test can proceed.
2. Complete training and instruction of the Owner's personnel as specified in the Sequencing and Scheduling article of Section 17050.

B. The performance test may be performed concurrently with the 7-day operational test specified in Section 01756.

C. General:
1. The performance test is part of the Work that must be completed as a condition of substantial completion for the entire Project.
2. The complete PLC control and SCADA system must run continuously for the duration of the performance test. During this period, exercise all system functions, and log for cause of failure, any system interruption and accompanying component, subsystem, or program failure:
    a. Include time of occurrence and duration of each failure.
3. Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system. Response time to the Project Site:
    a. 24 hours or less, for a major failure.
4. The performance test duration:
    a. 10 days.
5. Test and use the entire process control system under standard operating conditions.

D. SCADA system testing:
1. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
2. Failure of the SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
    a. Corrective action is required before restarting the acceptance test.

E. Failures:
1. Classify failures as either major or minor.
    a. Minor failure:
        1) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
        2) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
        3) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
        4) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
    b. Major failure:
        1) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper

operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.

2) Cause termination of the performance test.
3) Start a new acceptance test when the causes of a major failure have been corrected.
4) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

F. Technician report:
   1. Each time a technician is required to respond to a system malfunction, he or she must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
   2. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
   3. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
   4. Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example test forms:
   1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
   2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?		

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	SWITCHES **INSTALLATION AND CALIBRATION CHECKLIST**	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPEC SHEET

☐ VERIFIED PER P&ID NO

☐ CORRESPONDS TO SPECIFICATION SHEET NO.

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.

☐ INSTALLATION CORRECT PER DETAIL NO.

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? No Yes

FIELD CALIBRATION CHECK

CONTACT NO.	**FUNCTION**	**FOR SIGNAL**	**CONTACT IS TO**	**AT SPECIFIED VALUE FOR**		**ACTUAL TRIP POINT WAS…**	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	

NOTE: PERM IS ABBREVIATED FOR PERMISSIVE

	SWITCHES **INSTALLATION AND CALIBRATION CHECKLIST**	

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? No Yes

INSTRUMENT TYPE INDICATOR ☐ TRANSMITTER ☐ CONTROLLER ☐

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

HEAD CORRECTION = _____ ☐ LINEAR

CALIBRATED SPAN = _____ ☐ SQUARE ROOT

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET _____

☐ VERIFIED PER P&ID NO _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	**GAIN**	**PB**	**RESET (INTEGRAL)**	**DERIV. (RATE)**	**HIGH LIMIT**	**LOW LIMIT**	**ELEV. ZERO**	**ZERO SUPP**
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	**PB**	**RESET (REPEAT/MIN)**	**RESET (MIN/REPEAT)**	**DERIVATION (MINUTES)**
FLOW:	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	ANALYZERS **INSTALLATION AND CALIBRATION CHECKLIST**	

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? No Yes

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET _____

☐ VERIFIED PER P&ID NO _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES **INSTALLATION AND CALIBRATION CHECKLIST**	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THRU THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	DEVICENET INSTALLATION TESTING	

DeviceNet Network _____

Network Installation Characteristics

Architecture	Baud Rate	Trunk Media	Drop Media
☐ Single Master	☐ 125 kBaud	☐ Thick Round	☐ Thick Round, Unshielded
or			
☐ Multi Master	☐ 250 kBaud	☐ Thin Round	☐ Thin Round, Shielded
☐ Redundant Power Supplies	☐ 500 kBaud		☐ Thick Round, Shielded
☐ Per Network			

Installed Node List

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15
☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ 21 ☐ 22 ☐ 23 ☐ 24 ☐ 25 ☐ 26 ☐ 27 ☐ 28 ☐ 29 ☐ 30 ☐ 31
☐ 32 ☐ 33 ☐ 34 ☐ 35 ☐ 36 ☐ 37 ☐ 38 ☐ 39 ☐ 40 ☐ 41 ☐ 42 ☐ 43 ☐ 44 ☐ 45 ☐ 46 ☐ 47
☐ 48 ☐ 49 ☐ 50 ☐ 51 ☐ 52 ☐ 53 ☐ 54 ☐ 55 ☐ 56 ☐ 57 ☐ 58 ☐ 59 ☐ 60 ☐ 61 ☐ 62 ☐ 63

☐ All nodes present and in accordance with network drawings/specifications ☐ ODVA approved devices

☐ Nodes/devices accessible for inspection and maintenance ☐ Nodes/devices properly addressed

Comments: _____

Media Inspection

Trunk Cable	Drop Cable	Installation
☐ ODVA approved	☐ ODVA approved	☐ No evidence of physical damage
☐ Labeling complete	☐ Labeling complete	☐ Installed in protective raceway
☐ Cable/conductor terminations	☐ Cable/conductor terminations	☐ Bending radius not exceeded
☐ Terminating resistors at ends	☐ Max drop length < 20'	☐ Cable supports in place
		☐ V- and shield are grounded
		☐ Clearance from high temperature/voltage sources
		☐ No installation subject to vibration

Comments: _____

Network Power Supplies

Power Supply Equipment	Supply Source (120 VAC)	Network Power Tap (24 VDC)
☐ ODVA compliant	☐ Overcurrent protection	☐ Overcurrent protection
☐ Quantity and ratings	☐ Conductor size	☐ Conductor size

Comments:

CHECKED BY (COMPANY)	ACCEPTED BY (COMPANY)
SIGNATURE	SIGNATURE
DATE	DATE

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

General Network Description

The Profibus network serves the RO pretreatment, blended water, and concentrate processes and consists of both DP and PA slave devices. The master is located in programmable logic controller, PLC-900. Profibus DP repeaters are deployed in the network to essentially support a radial network topology from each process control panel.

Network Design Characteristics

ARCHITECTURE			**BAUD RATE (kbits/sec)**		
MASTER	☐ SINGLE	☐ REDUNDANT	☐ 9.6	☐ 187.5	☐ 3,000
TOTAL NODE COUNT ≤ 126	☐		☐ 19.2	☐ 50	☐ 6,000
REPEATER COUNT	_____		☐ 93.75	☐ 1,500	☐ 12,000
CASCADED REPEATER COUNT <9	_____				
NODE COUNT PER DP SEGMENT <32	☐				
DP/PA SEGMENT COUPLERS	_____				
REDUNDANCY (DP/PA COUPLERS	_____				
ACTIVE TERMINATORS	☐				
PROFIBUS DIAGNOSTICS	☐ PA ONLY	☐ DP & PA			
SURGE PROTECTION FOR SLAVES LOCATED OUTSIDE		☐			
SURGE PROTECTION FOR MEDIA ENTERING THE CONTROLLER CABINET		☐			
INTRINSIC SAFETY WIRING: REQUIRED FOR ANY PA NETWORK		☐			

INSTALLED NODE LIST

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	☐ 11	☐ 12	☐ 13	☐ 14	☐ 15									
☐ 16	☐ 17	☐ 18	☐ 19	☐ 20	☐ 21	☐ 22	☐ 23	☐ 24	☐ 25	☐ 26	☐ 27	☐ 28	☐ 29	☐ 30	☐ 31									
☐ 32	☐ 33	☐ 34	☐ 35	☐ 36	☐ 37	☐ 38	☐ 39	☐ 40	☐ 41	☐ 42	☐ 43	☐ 44	☐ 45	☐ 46	☐ 47									
☐ 48	☐ 49	☐ 50	☐ 51	☐ 52	☐ 53	☐ 54	☐ 55	☐ 56	☐ 57	☐ 58	☐ 59	☐ 60	☐ 61	☐ 62	☐ 63									
☐ 64	☐ 65	☐ 66	☐ 67	☐ 68	☐ 69	☐ 70	☐ 71	☐ 72	☐ 73	☐ 74	☐ 75	☐ 76	☐ 77	☐ 78	☐ 79									
☐ 80	☐ 81	☐ 82	☐ 83	☐ 84	☐ 85	☐ 86	☐ 87	☐ 88	☐ 89	☐ 90	☐ 91	☐ 92	☐ 93	☐ 94	☐ 95									
☐ 96	☐ 97	☐ 98	☐ 99	☐ 100	☐ 101	☐ 102	☐ 103	☐ 104	☐ 105	☐ 106	☐ 107	☐ 108	☐ 109	☐ 110	☐ 111									
☐ 112	☐ 113	☐ 114	☐ 115	☐ 116	☐ 117	☐ 118	☐ 119	☐ 120	☐ 121	☐ 122	☐ 123	☐ 124	☐ 125	**R** 126	**R** 127									

☐ ALL NODES PRESENT IN ACCORDANCE WITH NETWORK DESIGN DOCUMENTS.

LEGEND

M MASTER NODE PRESENT AT THIS ADDRESS

D PROFIBUS DP NODE PRESENT AT THIS ADDRESS

P PROFIBUS PA NODE PRESENT AT THIS ADDRESS

R RESERVED ADDRESS

☐ NO DEVICE PRESENT AT THIS ADDRESS

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME:		TEST DATE:	
FACILITY NAME:		TESTED BY:	
PROCESS AREA:		COMPANY:	
NETWORK ID:		PAGE:	
WITNESSED BY:		SIGNATURE:	

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

Media Inspection

CABLING	DP NETWORK	PA NETWORK SEGMENTS			
PI COMPLIANT	☐	☐	☐	☐	☐
LABELING COMPLETE	☐	☐	☐	☐	☐
GROUNDING	☐	☐	☐	☐	☐
CABLE AND CONDUCTOR TERMINATIONS	☐	☐	☐	☐	☐
NO STUB LINES (DP ONLY)	☐	☐	☐	☐	☐
TERMINATING RESISTORS (IN PLACE)	☐	☐	☐	☐	☐
DEDICATED DIAGNOSTICS BUS	☐	☐	☐	☐	☐
INSTALLATION					
NO EVIDENCE OF PHYSICAL DAMAGE	☐	☐	☐	☐	☐
INSTALLATION IN PROTECTIVE RACEWAY	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH TEMPERATURE SOURCES	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH VOLTAGE SOURCES	☐	☐	☐	☐	☐
BEND RADIUS	☐	☐	☐	☐	☐
NO. INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE	☐	☐	☐	☐	☐
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION	☐	☐	☐	☐	☐

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

Device Inspection

DEVICE QUANTITY/TYPE	INSTALLATION
☐ TOTAL SLAVE COUNT	☐ NO EVIDENCE OF PHYSICAL DAMAGE
☐ MOST UPDATED DEVICE DRIVER INSTALLED?	☐ ACCESSIBLE FOR INSPECTION AND MAINTENANCE
☐ INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS	☐ FDT COMPLIANT DEVICES
☐ PI COMPLIANCE DEVICES	
☐ DIAGNOSTICS MODULE INSTALLED	

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

Power Supplies

ACTIVE TERMINATIONS	COUPLERS	REPEATERS
☐ SOURCE LOCATION	☐ SOURCE LOCATION	☐ SOURCE LOCATION
☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION
☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE
☐ GROUNDING	☐ GROUNDING	☐ GROUNDING

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: _____ TEST DATE: _____

FACILITY NAME: _____ TESTED BY: _____

PROCESS AREA: _____ COMPANY: _____

NETWORK ID: _____ PAGE: _____

WITNESSED BY: _____ SIGNATURE: _____

PROFIBUS
INSTALLATION QUALIFICATION AND TESTING

DP Network Media Testing

DESCRIPTION	SEGMENT ID					
TRUNK LENGTH (feet)						
ALLOWABLE TRUNK LENGTH AT SPECIFIED DATA RATE:						
MEASURED TRUNK LENGTH:						
SPARE TRUNK LENGTH						
RESISTANCE MEASUREMENTS (ohms)						
NETWORK CABLE: NO TERMINATIONS						
ONE TERMINATION						
TWO TERMINATIONS						
POWER SUPPLY VOLTAGE (volts DC)						
ACTIVE TERMINATOR						
REPEATER CP1100-RPT1						
REPEATER CP1000-RPT1						
REPEATER CP1000-RPT2						
REPEATER CP2700-RPT1						

CABLE TESTS	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES AND SHIELD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHIELD CONTINUITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR OPEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CROSSED SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CORRECT TERMINATOR POSITION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
CORRECT CABLE TYPE AND LENGTH	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SECURE & TIGHT CONNECTORS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

COMMENTS *(Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)*

PROJECT NAME: _____ TEST DATE: _____

FACILITY NAME: _____ TESTED BY: _____

PROCESS AREA: _____ COMPANY: _____

NETWORK ID: _____ PAGE: _____

WITNESSED BY: _____ SIGNATURE: _____