SECTION 40 05 00 – PIPING, GENERAL

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide the piping systems indicated, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to piping sections in Divisions 33 and 40.

C. The Drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type.

D. The Drawings are not pipe construction or fabrication drawings. CONTRACTOR shall prepare pipe spooling and fabrication drawings and shall submit to the ENGINEER for review.

E. Where pipe supports and spacing are indicated on the Drawings and are referenced to a Standard Detail, the CONTRACTOR shall use that Detail.

F. Where pipe supports are not indicated on the Drawings, it is the CONTRACTOR'S responsibility to develop the details necessary to design and construct mechanical piping systems to accommodate the specific equipment provided, and to provide spacers, adapters, and connectors for a complete and functional system.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A.	AISI C 1012	Carbon Steel
B.	ANSI/ASME B1.1	Unified Inch Screw Threads, (UN and UNR Thread Form).
C.	ANSI/ASME B1.20.1	Pipe Threads, General Purpose (inch).
D.	ASCE 7-05	Minimum Design Loads for Buildings and Other Structures
E.	ASME B16.5	Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and other Special Alloys.
F.	ASME B 31	Standards for Pressure Piping
G.	ASME Section 9	Boiler and Pressure Vessel Code
H.	ASTM A 36	Standard Specification for Carbon Structural Steel
I.	ASTM A 108	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
J.	ASTM A 167	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
K.	ASTM A 193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
L.	ASTM A 194	Standard Specification for Carbon Steel, Alloy Steel, and

	Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
M. ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
N. ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes
O. ASTM A 307	Specification for Carbon Steel Bolts and Studs, 6,000 psi Tensile.
P. ASTM A 325	Specification for High-Strength Bolts for Structural Steel Joints.
Q. ASTM F 436	Standard Specification for Hardened Steel Washers
R. ASTM F 467	Standard Specification for Nonferrous Nuts for General Use
S. ASTM F 468	Standard Specification for Nonferrous Bolts, Hex Cap Screws, Socket Head Cap Screws, and Studs for General Use
T. ASTM A 512	Standard Specification for Cold-Drawn Buttweld Carbon Steel Mechanical Tubing
U. ASTM A 513	Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
V. ASTM A 563	Standard Specification for Carbon and Alloy Steel Nuts
W. ASTM A 576	Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
X. ASTM D 792	Test Methods for Specific Gravity and Density of Plastics by Displacement.
Y. ASTM F 844	Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
Z. AWS D1.1	Structural Welding Code
AA. AWWA M 11	Steel Pipe – A Guide for Design and Installation
BB. AWWA C 115	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
CC. AWWA C 207	Steel Pipe Flanges for Water Works Service, Sizes 4 in through 144 in.
DD. AWWA C 209	Standard for Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines

EE. AWWA C 219 — Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe.

FF. AWWA C 606 — Grooved and Shouldered Joints.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings: Shop Drawings shall contain the following information:

1. Drawings: Layout drawings including necessary dimensions, details, pipe joints, fittings, specials, bolts and nuts, gaskets, valves, appurtenances, anchors, guides, design calculations, and material lists. Pipe spooling and fabrication drawings shall indicate spacers, adapters, connectors, fittings, and pipe supports to accommodate the equipment and valves in a complete and functional system.

2. Pipe Supports: Submit pipe support fabrication drawings including calculations signed by a Registered Engineer in accordance with Section 40 05 07 – Pipe Supports.

3. Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified with the applicable style or series designation.

4. Thermoplastic Pipe Joints: Submit solvent cement manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

5. Gasket Material: Submit gasket manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

6. Seals and Seating Materials: Submit elastomer material and manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

7. Modular Seals for Pipe: Manufacturer's catalog sheet showing materials and installation procedures.

C. Samples

1. Performing and paying for sampling and testing as necessary for certifications are the CONTRACTOR'S responsibility.

D. Certifications

1. Necessary certificates, test reports, and affidavits of compliance shall be obtained by the CONTRACTOR.

2. A certification from the pipe fabricator that each pipe will be manufactured subject to the fabricator's or a recognized Quality Control Program. An outline of the program shall be submitted to the ENGINEER for review prior to the manufacture of any pipe.

1.4 MATERIAL DELIVERY, STORAGE, AND PROTECTION

A. Piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground for protection against oxidation caused by ground contact.

B. Defective or damaged materials shall be replaced with new materials.

PART 2 – PRODUCTS

2.1 GENERAL

A. Extent of Work

1. Pipes, fittings, and appurtenances shall be provided in accordance with the requirements of the applicable Sections of Divisions 33 and 40 and as indicated.

2. Materials in contact with potable water shall be listed as compliant with NSF Standard 61.

3. All materials, fittings and appurtenances intended for use in pressure pipe systems shall be designed and constructed for a minimum working pressure of 150 psi unless the specific application dictates a higher working pressure.

4. All dead ends (temporary and permanent) shall be mechanically restrained (plug is required). Thrust block restraint is not allowed.

B. Piping Supports

1. Pipes shall be adequately supported, restrained, and anchored in accordance with Section 40 05 07 – Pipe Supports, and as indicated.

C. Lining

1. Application, thickness, and curing of pipe lining shall be in accordance with the applicable Sections of Division 33, unless otherwise indicated.

D. Coating

1. Application, thickness, and curing of coating on buried pipe shall be in accordance with the applicable Sections of Division 33, unless otherwise indicated.

2. Pipes shall be coated in accordance with Section 09 96 00 – Protective Coating.

E. Pressure Rating

1. Piping systems shall be designed for the maximum expected pressure as defined in Section 01 74 30 – Pressure Pipe Testing and Disinfection, or as indicated on the Piping Schedule, whichever is greater.

F. Grooved Piping Systems

1. Piping systems with grooved joints and fittings may be provided in lieu of screwed, flanged, welded, or mechanical joint systems for steel and ductile iron yard piping. (All piping above and below ground within the property limits of treatment plants, pump stations, and similar installations). All grooved couplings on buried piping must be bonded. To assure uniform and compatible piping components, all grooved fittings, couplings, and valves shall be from the same manufacturer. The CONTRACTOR shall make the coupling manufacturer responsible for the selection of the correct style of coupling and gasket for each individual location.

G. Inspection

1. Pipe shall be subject to inspection at the place of manufacture.

2. During the manufacture, the ENGINEER shall be given access to areas where manufacturing is in progress and shall be permitted to make inspections necessary to confirm compliance with requirements.

H. Tests

1. Except where otherwise indicated, materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards.

2. Welds shall be tested as indicated.

3. The CONTRACTOR shall be responsible for performing material tests at no additional cost to the OWNER.

I. Welding Requirements

1. Qualification of welding procedures used to fabricate pipe shall be in accordance with the provisions of AWS D1.1 - Structural Welding Code or the ASME Boiler and Pressure Vessel Code, Section 9, whichever is applicable.

2. Welding procedures shall be submitted for the ENGINEER's review.

J. Welder Qualifications

1. Welding shall be performed by skilled welders and welding operators who have adequate experience in the methods and materials to be used.

2. Welders shall be qualified under the provisions of AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9, whichever is applicable.

3. Machines and electrodes similar to those used in the WORK shall be used in qualification tests.

4. Qualification testing of welders and materials used during testing is part of the WORK.

K. DIP and PVC Transition

1. Transitions between DIP and PVC that are not specified or required by the construction plans or details are not permitted. PVC SDR-35 sewer pipe/ductile iron pipe adapters shall be used for DIP and PVC transition on all new constructions. Heavy duty stainless steel flexible couplings are acceptable for transition joints with existing facilities only.

L. Tapping:

1. Existing mains may be tapped as long as the tapping line is smaller than the tapped line. No size-on-size taps are permitted. Equal size lines branch-offs shall require that a tee be cut in. A ductile iron mechanical joint tapping sleeve is required for all taps unless the tapping line is half the diameter or less of the line to be tapped. A stainless steel tapping sleeve is permissible in those cases. Use of a stainless steel sleeve is also permissible on all size taps on existing SDR-26 and SDR-21 PVC pipe only. Cut-in tee construction may be specified, depending on the circumstances and sizes involved.

2. Tapping Sleeves and Tapping Valves

a. Provide ductile iron, mechanical joint x flanged outlet tapping sleeves. Factory epoxy coated steel tapping sleeves are permissible on existing SDR-26 and SDR-21 PVC pipe only.

b. Provide as a tapping valve a mechanical joint x flanged outlet, iron body, resilient seat gate valve, conforming to those described in these Specifications.

c. Pressure test the tapping sleeve and valve at 150 psi for one hour. The OWNER and the ENGINEER (if applicable) must be given not less than 48 hours advance notice of the test and must be present to witness the test.

d. The pipe coupon will be carefully preserved and turned over to the OWNER.

e. Provide double strap tapping saddles with AWWA threads and ball valve corp stop with operating nut gate valve for 1-1/2" and 2" taps.

f. Provide double strap tapping saddle with AWWA threads and corporation stop with AWWA inlet threads for taps 1" and smaller.

g. All taps must be not less than 18" from a fitting or bell.

h. The tapping line must be smaller than the tapped line, except as approved by the OWNER and the ENGINEER.

i. A ductile iron tapping sleeve is required for all taps unless the tapping line is less than 1/2 the diameter of the line to be tapped. A steel tapping sleeve is permissible in those cases.

j. Cut-in tee construction may be required by the OWNER depending on the circumstances and sizes involved.

3. Tapping Saddles

a. Tapping saddles shall be used for all taps three inches in diameter or less.

b. Tapping saddles shall be the double-strap, steel-constructed type conforming to AWWA C-800 requirements.

c. Saddles shall be brass with stainless steel hardware with extra wide bearing surfaces furnished with a flanged or NPT threaded outlet.

d. Saddles shall be rated for 150 psi working pressure and shall be furnished with extra thick and wide neoprene gasket.

e. Service saddles shall be as manufactured by Clow or approved equal.

2.2 PIPE FLANGES

A. General

B. Flanges shall be provided with flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise indicated.

C. Flange faces shall be perpendicular to the axis of the adjoining pipe.

D. Flanges for miscellaneous small diameter pipes shall be in accordance with the standards indicated for these pipes.

E. Pressure Ratings

1. 150 psig or less: Flanges shall conform to either AWWA C207 - Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ASME B16.5 - Pipe Flanges and Flanged Fittings, 150 lb. class. For ozone and oxygen piping, use weld-neck flanges.

2. 150 psig to 275 psig: Flanges shall conform to either AWWA C207 Class E or Class F, or ASME B16.5 150 lb. class.

3. 275 psig to 500 psig: Flanges shall conform to ASME B16.5, 300 lb. class.

4. Selection Based on Test Pressure

   a. Do not expose AWWA flanges to test pressures greater than 125 percent of rated capacity.

   b. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected.

F. Blind Flanges

1. Provide blind flanges in accordance with AWWA C207, or as indicated for miscellaneous small pipes.

2. Blind flanges for pipe sizes 12-inches and greater shall be provided with lifting eyes in the form of welded or screwed eye bolts.

G. Flange Coating

1. Machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

H. Flange Fasteners

1. Unless otherwise shown on the drawings, or indicated in the applicable Sections of Divisions 33 and 40, Bolts and nuts shall conform to the following requirements;

   a. Threads shall be in accordance with ANSI/ASME B1.1, Class 2, UNC for bolt diameters 1" and smaller and UN8 for bolt diameters greater than 1".

   b. Bolts shall have heavy hexagon heads and heavy hexagon nuts. Length of studs shall provide a projection of not less than 0.25 inch and no more than 0.5 inch through the nut when it is drawn tight.

   c. Thread studs on flange connections are not permitted except where space restrictions preclude the use of standard bolts.

   d. Through bolt holes shall be drilled in accordance with the applicable flange standard.

   e. All bolts fastening metallic flanges shall be provided with plain washers installed under the nut. Washer materials shall be of the same material as the bolt. If the through bolt holes are drilled larger than the applicable standard by 1/8 inch in diameter or more, bolts shall be also installed with a plain washer under the bolt head as well.

f. All bolts fastening non-metallic flanges shall be provided with plain washers installed under both the bolt head and nut. Washer materials shall be of the same material as the bolt.

g. Anti-seize compound shall be used on carbon steel fasteners, and shall be **Husk-ITT, Husky 2000; or approved equal.**

h. Anti-galling compound used for stainless steel fasteners in LOX, nitrogen injection, oxygen, ozone process/off-gas/vent and ozone contactor maintenance air service shall be **Dupont "Krytox"; or approved equal.**

i. Anti-galling compound used for stainless steel fasteners for all other services shall be certified for potable water use and shall be **Husk-ITT, Lube O'seal; Hercules, Real-Tuff; La Co, Slic-Tite; or approved equal.**

2. Fastener Material Group Numbering System

a. Flange fasteners shall conform to the following material standards and shall be categorized within the Fastener Material Schedule Groups as indicated:

1) Material Group C1 (Carbon steel) = ASTM A307 Grade B bolts, ASTM A563 Grade B nuts.

2) Material Group C2 (Carbon steel) = ASTM A193 Grade B7 bolts, ASTM A194 Grade 2H nuts.

3) Material Group S1 (316 SS) = ASTM A193, Grade B8M bolts, ASTM A194 Grade 8M nuts.

4) Material Group S2 (304 SS) = ASTM A193, Grade B8 bolts, ASTM A194 Grade 8F nuts.

5) Washers for carbon steel fasteners, if applicable, shall be provided with hardened steel conforming to ASTM F436.

6) Washers for stainless steel fasteners, if applicable, shall conform to ASTM F844, material ASTM A167, Type 316 or ASTM A276, Type 316.

3. Fastener Material Group Numbers used in Non-Corrosive Service Applications

a. Flanges per AWWA C207 steel flanges.

1) Class B and D flanges – Material Group C1

2) Class E and F flanges. – Material Group C2

b. AWWA C115 Ductile Iron Flanges - Material Group C1

c. ASME B31 group piping flanges – Material Group C2

d. Non-metallic pipe flanges - Material Group S1

e. Stainless steel pipe flanges and all others not listed above - Material Group S1

f. Where mating flanges are of different flange material standards and the specified Fastener Material Groups are in conflict, then fasteners of the higher grade shall

be utilized unless otherwise indicated. For the purpose of this requirement, the Material Groups in order of decreasing grade shall be S1, S2, C2 and C1.

g. Where gaskets of Teflon or Viton-A are required, fasteners of Material Group C2 shall be utilized for all flange standards in lieu of those listed above.

4. Fastener Material Group Numbers used in Corrosive Service Applications

1) Corrosive service shall be as defined in accordance with Section 05 50 00 Miscellaneous Metalwork.

2) All Flange fasteners shall be of Material Group S1 unless S2 is otherwise indicated.

I. Insulating Flanges

1. Insulated flanges shall be provided with bolt holes 1/4-inch diameter greater than the bolt diameter.

J. Insulating Flange Sets

1. Insulating flange sets shall be furnished on all piping connections where two dissimilar metals are to be connected in order to prevent corrosion. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers, and a steel washer.

2. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inch or smaller and shall be made of acetyl resin.

3. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be 2-piece and shall be made of polyethylene or phenolic material.

4. Steel washers shall be in conformance with ASTM A 325 - Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

5. Insulating flange sets materials used for fluids other than general water and wastewater shall be made of materials compatible with the fluid services.

6. Insulating gaskets shall be full-face.

K. Insulating Flange Manufacturer, or Approved Equal

1. **JM Red Devil, Type E**

2. **Maloney Pipeline Products Co.**

3. **PSI Products, Inc. (Garlock Pipeline Technologies)**

L. Flange Gaskets

1. Gaskets for flanged joints used in general water and wastewater service shall be full-faced type, with material and thickness in accordance with AWWA C207, suitable for temperatures to 700 degrees F, a pH of one to 11, and pressures to 1000 psig.

2. Blind flanges shall be provided with gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange.

3. Ring gaskets will not be accepted unless otherwise indicated.

1. Flanged gaskets shall be **Toroseal** gaskets as manufactured by American Pipe or **Flange-Tyte** gaskets as manufactured by US pipe.

2. Gaskets for flanged joints used in water with chloramines shall be Teflon material, NSF 61 approved, **Garlock, Gylon Style 3505, John Crane, or approved equal.**

3. Gaskets for flanged joints used in water with ozone shall be Teflon material, NSF 61 approved, **Garlock, Gylon, Style 3504, John Crane, or approved equal.** Contractor shall furnish high strength bolts in accordance with ASTM A325 at all locations where flanges are provided for water with dissolved ozone residual.

4. Gaskets for flanges for PVC and CPVC piping used in general water and wastewater service shall be NSF 61 approved, full-faced, 1/8-inch thick, and made of fluoroelastomer having a durometer hardness of 50 to 70. Gaskets for pipe sizes up to 24-inch and 150 psi shall be **Garlock Style XP, John Crane, or approved equal.**

5. When the mating flange has a raised face, provide stainless steel flat ring gasket filler between the PVC flange and gasket and the adjacent flange.

6. Gaskets for flanged joints used in chemicals, hot air, ozone gas, solvents, hydrocarbons, steam, chlorine and other fluids shall be made of materials compatible with the service, pressure, and temperature. Consult gasket Manufacturer for recommended gasket material.

2.3 THREADED INSULATING CONNECTIONS

A. General

1. Threaded insulating bushings, unions, or couplings, as appropriate, shall be furnished for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. Materials

1. Threaded insulating connections shall be constructed of nylon, Teflon, polycarbonate, polyethylene, or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

A. General

1. Provide cast mechanical-type couplings where indicated, conforming to the requirements of AWWA C606 - Grooved and Shouldered Joints.

2. Bolts and nuts shall conform to the requirements of Section 05 50 00 – Miscellaneous Metalwork.

3. Elastomers for seal materials shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. Where couplings are used in water containing dissolved ozone residual or chloramines, seal material shall be Viton-A.

4. Grooved or banded piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure.

a. If grooved connections are used, the remaining thickness of pipe material after grooving shall be adequate to carry the load imparted to the joint. Joints for thin wall pipes shall be banded or welded

b. Method of connection for metallic pipes using rolled pipe ends shall not be acceptable.

c. Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends.

5. In order to avoid excessive load on equipment caused by pipe movement due to steady state or transient pressure conditions, equipment connections with mechanical-type couplings shall be provided with rigid grooved couplings or flexible type coupling with harness in sizes where rigid type couplings are not available, unless thrust restraint is provided by other means.

6. Mechanical type couplings shall be electrically bonded.

7. The CONTRACTOR shall have the coupling manufacturer's service representative verify the correct choice and application of couplings and gaskets, and the workmanship, to assure a correct installation.

8. In order to assure uniform and compatible piping components, grooved fittings, couplings, and valves shall be furnished by the same manufacturer as the coupling.

9. Grooving tools shall be from the same manufacturer as the grooved components.

B. Steel Pipe Couplings Manufacturer, or approved equal

1. **Victaulic Style 41 or 44** (banded, flexible)

2. **Victaulic Style 177 / 77 / W77** (grooved, flexible or rigid)

3. **Victaulic Style 107H / 07 / W07 or HP-70** (grooved, rigid)

C. Ductile Iron Pipe Couplings Manufacturer, or approved equal

1. **Victaulic Style 31** (flexible or rigid grooving)

Note: Ductile iron pipe couplings shall be provided with flush seal gaskets.

D. PVC Pipe Couplings Manufacturer, or approved equal

1. **North American Specialty Products**

2. **Victaulic Aquamine Products, Series 2900**

2.5 SLEEVE–SPLIT TYPE COUPLINGS

A. General

1. Provide sleeve-split type couplings where indicated.

B. Construction

1. Couplings shall be of the split-type, consisting of one- or 2-piece housing, gasket assembly, bolts and nuts, and end rings.

2. The double arch cross section that closes around the pipe ends shall be smooth in order to allow for expansion or contraction requirements.

3. The pipe ends with steel end rings affixed shall provide restraint requirements.

4. As the coupling closes, it shall confine the elastomeric gasket beneath the arches of the sleeve to create a radial seal.

5. The axial seal shall squeeze the closure plates as the bolts pull the coupling snug around the pipe.

6. Elastomers for seal materials shall be compatible with the piping service, in accordance with the coupling manufacturer's recommendations. Where couplings are used in water containing dissolved ozone residual or chloramines, seal material shall be Viton-A.

7. The coupling shall permit angular pipe deflection, flexibility, contraction and expansion, as designed by the manufacturer.

8. The coupling housing shall be designed for internal pressure and external loads as determined by the design procedures of AWWA M-11.

9. The coupling shell thickness of the steel coupling shall be calculated using the formula:

$$T=PwDy/2Fs$$

Where:

T = steel coupling thickness, in.

Dy = pipe outside diameter, in.

Pw = Design working pressure, psi

Fs = 50 percent of minimum yield point of steel, psi

10. Coupling design calculations shall be stamped and signed by a registered engineer and shall be included in the Shop Drawing submittal for couplings.

11. The sealing members shall be comprised of 2 O-ring gaskets and an elastomer sealing pad bonded to sealing plate.

12. Internal pressure shall not be required to make the seal.

C. Materials

1. Unless otherwise indicated, the coupling housing material shall be the same material as the piping.

2. Couplings

   a. Carbon steel couplings shall be fabricated from ASTM A 36.

   b. Stainless steel couplings shall be fabricated from ASTM A 240, Type - 304, 304L, 316, or 316L.

3. Restraint End Rings

   a. Carbon steel end rings shall conform to ASTM A 108 Grade 1018.

   b. Stainless steel end rings shall conform to ASTM A 276 Type - 316L.

4. Bolts and nuts shall be in conformance with the requirements of Section 05 50 00 – Miscellaneous Metalwork.

5. Carbon steel couplings shall be fusion bond epoxy-coated inside and outside of the coupling in accordance with the requirements of Section 09 96 00 – Protective Coating.

6. Wrapping

   a. Couplings installed underground shall be provided with **Depend-O-Wrap tape or approved equal.**

   b. The application of wrapping material shall be in conformance with AWWA C209.

D. Pipe Preparation

1. Ends of pipes shall be prepared for the flexible split sleeve type couplings inspected and approved by the coupling manufacturer.

2. The pipe outside diameter and roundness tolerances shall comply with tolerances listed in AWWA C219.

3. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the end of the pipe.

4. End Rings

   a. Provide end rings with couplings when restraint is required.

   b. Carbon steel end rings shall be constructed of ASTM A 108 Grade 1018.

   c. Stainless steel end rings shall conform to ASTM A 276 Type - 316L.

5. Where the split-type coupling is used to take up thermal expansion or contraction **(Depend-O-Lok F X E or approved equal)** at the pipe joint, one end ring shall be fixed to one end of the pipe in order to keep the coupling in the proper location.

6. Fully-Restrained Joints

   a. Where the split-type coupling is used for a fully-restrained pipe joint **(Depend-O-Lok F X F or approved equal)** at the pipe joint, one end ring shall be welded to each of the pipe ends to fit beneath the coupling and shall be protected by the coating.

   b. Welding design and specification shall be in conformance with the coupling manufacturer's recommendations.

E. Sleeve-Split Type Couplings Manufacturer, or approved Equal

1. **Victaulic**

2.6 SLEEVE-TYPE COUPLINGS

A. General

1. Provide sleeve-type couplings where indicated.

2. The CONTRACTOR will not be allowed to substitute any other type of coupling in lieu of sleeve coupling unless approved by the ENGINEER.

B. Construction

1. Sleeve couplings shall be in accordance with AWWA C219 - Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe.

2. Couplings shall be constructed of steel with steel bolts, without pipe stop.

3. Couplings shall be of sizes to fit the indicated pipe and fittings.

4. The middle ring shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected.

5. If the strength of the middle ring material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.

6. The coupling shall be either 5 or 7 inches long for sizes up to and including 30-inch and 10 inches long for sizes greater than 30-inch, for standard steel couplings, and 16 inches long for long-sleeve couplings.

7. The followers shall be single-piece contoured mill sections welded and cold-expanded as required for the middle rings and of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling.

8. The shape of the follower shall be of such design as to provide positive confinement of the gasket.

9. Bolts and nuts shall be in accordance with the requirements of Section 05 50 00 – Miscellaneous Metalwork.

10. Buried sleeve-type couplings shall be epoxy-coated at the factory as indicated.

C. Pipe Preparation

1. Where indicated, prepare the ends of the pipe for flexible steel couplings.

2. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the ends of the pipe, with an outside diameter not more than 1/64 inch smaller than the nominal outside diameter of the pipe.

3. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, in order to proof-test the weld to the strength of the parent metal.

4. The weld of the middle ring shall be subjected to air test for porosity.

D. Seals

1. Seal elastomer materials for couplings shall be selected to be compatible with the fluid service, pressure and temperature. They shall be composed of elastomeric-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions.

2. Where couplings are used in water containing ozone or chloramines, seal material shall be Viton-A.

3. Where couplings are used for fluids which are not compatible with rubber materials, the elastomeric seal material shall be compatible with the piping service and fluid utilized.

E. Piping Connection to Equipment

1. Where couplings are shown to connect piping to mechanical equipment such as pumps, compressors, and blowers, the piping shall be aligned with the equipment point of connection and shall be perpendicular to the axis of the flange or fitting for which the piping is to be connected.

2. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment.

3. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.

F. Insulating Sleeve Couplings

1. Where insulating couplings are required, both ends of the coupling shall be provided with a wedge-shaped gasket which assembles over a sleeve of an insulating compound material compatible with the fluid service in order to obtain insulation of coupling metal parts from the pipe.

G. Restrained Joints

1. Sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means.

2. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated.

3. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed.

4. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation in order to prevent misalignment of the pump imparted by the thrust within the piping system.

H. Sleeve-Type Couplings Manufacturer, or approved Equal

1. **Dresser, Style 38**

2. **Ford Meter Box Co., Inc., Style FC1 or FC3**

3. **Smith-Blair, Style 411**

2.7 FLEXIBLE SLEEVE TYPE COUPLINGS FOR DIFFERING PIPE MATERIALS/DIAMETERS IN BURIED APPLICATIONS

A. Flexible sleeve type couplings to connect different pipe types shall be of corrosion resistant rubber or PVC with Type 316 stainless steel clamp bands; Flexible sleeve type couplings shall be as manufactured by **Fernco, Mission Rubber Company, Inc., Calder**, or approved equal. All couplings shall conform to ASTM 425 and installed per manufacturers requirements.

2.8 FLANGED COUPLING ADAPTERS AND DISMANTLING JOINTS

A. Provide couplings where indicated.

B. The CONTRACTOR will not be allowed to substitute any other type of coupling in lieu of the couplings as specified herein unless approved by the ENGINEER.

C. The coupling shall be rated as indicated.

D. Construction

1. Coupling bodies shall be fabricated from steel, ASTM A 512 - Cold-Drawn butt-weld Carbon Steel Mechanical Tubing or A 513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing with steel bolts, without pipe stop.

2. Provide flanges in conformance with AWWA C207.

3. Couplings shall be of sizes to fit the indicated pipe and fittings.

4. The body shall be not less than 1/4 inch thick or at least the same wall thickness as the pipe to which the coupling is connected.

5. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.

6. The follower flange shall be fabricated from steel, ASTM A 576 - Steel Bars, Carbon, Hot Wrought, Special Quality or AISI C1012.

7. The shape of the follower shall be of such design as to provide positive confinement of the gasket.

8. Bolts and nuts shall be in accordance with the requirements of Section 05 50 00 – Miscellaneous Metalwork.

9. Buried couplings shall be epoxy-coated at the factory as indicated.

E. Seals

1. Seal elastomer materials for couplings shall be selected to be compatible with the fluid service, pressure and temperature. They shall be composed of elastomeric-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions.

2. Where couplings are used in water containing ozone or chloramines, seal material shall be Viton-A.

3. Where couplings are used for fluids which are not compatible with rubber materials, the elastomeric seal material shall be compatible with the piping service and fluid utilized.

F. Piping Connections to Equipment

1. Where couplings are shown to connect piping to mechanical equipment such as pumps, compressors, and blowers, the piping shall be aligned with the equipment point of connection and shall be perpendicular to the axis of the flange or fitting for which the piping is to be connected.

2. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment.

3. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.

G. Restrained Joints on flanged coupling adapters

1. Flanged coupling adapters on pressure lines shall be harnessed unless thrust restraint is provided by other means.

2. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated.

3. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed.

4. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation in order to prevent misalignment of the pump imparted by the thrust within the piping system.

5. Other means of restraining the coupling such as set screws will not be accepted.

H. Flanged Couplings Adapter Manufacturer, or approved equal

1. **Smith-Blair, Model 913**

2. **Dresser, Model 128-W**

3. **JCM, Model 303**

I. Dismantling Joints Manufacturer, or approved equal

1. **Smith-Blair, Model 975**

2. **Dresser, Model 131**

3. **JCM, Model 309**

2.9 FLEXIBLE CONNECTORS

A. Low-Temperature

1. Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment, and where indicated.

2. Flexible connectors for service temperatures up to 180 degrees F shall be flanged-reinforced neoprene or butyl spools, rated for a working pressure of 40 to 150 psig, or reinforced flanged duck and rubber, as best suited for the application.

3. Flexible connectors for service temperatures above 180 degrees F shall be flanged, braided stainless steel spools with inner, annular, corrugated stainless steel hose, rated for a minimum 150-psig working pressure, unless otherwise indicated.

4. The connectors shall be a minimum of 9 inches long and provided with face-to-face flanges, unless otherwise indicated.

5. The final material selection shall be approved by the manufacturer.

6. The CONTRACTOR shall submit manufacturer's Shop Drawings and calculations.

B. High-Temperature

1. Install flexible connectors in engine exhaust piping and where indicated.

2. Connectors shall be sufficient to compensate for thermal expansion and contraction and to isolate vibration between the engine and the exhaust piping system.

3. Connectors shall be stainless steel bellows-type, flanged, and rated for minimum 150 psig, 2000 degrees F.

C. Flexible Connections for Chemical Tanks

1. Flexible connectors for chemical tanks shall be constructed of molded PTFE with at least two convolutions and flanged joints. Flanges shall be ductile iron with Type 316 stainless steel bolts and nuts.

2. Flexible connector shall be **Proco Series 442 molded expansion joint, or approved equal.**

2.10 EXPANSION JOINTS

A. Piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement without exertion of undue forces to equipment or structures, accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints.

B. Expansion joints shall be provided with flanged ends and constructed of stainless steel, Monel, rubber, or other materials best suited for each individual service. Where expansion joints are used in water containing dissolved ozone residual or chloramines, provide Type 316 stainless steel material expansion joints.

C. Where bellows-type expansion joints are mounted near the suction nozzle of the pump, stainless steel internal liner shall be provided to minimize turbulence as the flow passes through the arches of the bellows.

D. CONTRACTOR shall submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature, and pressure ratings.

2.11 PIPE THREADS

A. Pipe threads shall be in conformance with ASME B1.20.1 - Pipe Threads, General Purpose (inch), and be made up with Teflon tape unless otherwise indicated.

2.12 PIPE INSULATION

A. Hot and cold liquid piping, flues, and engine exhaust piping shall be insulated as indicated and in accordance with the requirements of Section 43 10 70 – Pipe, Ductwork, and Equipment Insulation.

B. No unprotected hot piping shall be within reach of operating personnel or other persons.

C. Pre-insulated pipe for underground service shall be in accordance with the requirements of Section 43 10 68 – Pre-Insulated Pipe.

2.13 MODULAR MECHANICAL SEALS FOR PIPING PENETRATIONS

A. Where indicated and where required in order to prevent flow of water or air, the passages of piping through wall sleeves and cored openings shall be sealed with modular interlocking link mechanical closures.

B. Individual links shall be constructed of EPDM rubber, be suitable for temperatures between minus 40 and plus 250 degrees F, and be shaped to fill the annular space between the outside of the pipe and the inside of the wall sleeve or cored opening.

C. Assemble the links using Type 316 stainless steel bolts and nuts to form a continuous rubber belt around the pipe.

D. Pressure plates under each bolt and nut shall be fabricated of a corrosion-resistant composite material.

E. After the seal assembly is positioned in the sleeve, tighten the bolts against the pressure plates to expand the rubber links and form the watertight seal.

F. Sizing and installation of sleeves and assemblies shall be in accordance with the manufacturer's recommendations.

G. Modular Mechanical Seals Manufacturer, or approved equal

1. **Thunderline Corporation, Link-Seal**

2. **Proco, Pen-Seal**

2.14 SAMPLE POINTS (WATER TRANSMISSION MAINS)

A. Install sample taps required to take all necessary water samples at points designated on the Contract Drawings.

B. Provide 3/4" type "K" copper tubing or schedule 40 PVC for all in-line sample points.

C. The CONTRACTOR will make arrangements for a certified laboratory to take all water samples required for bacteriological tests.

D. Water main being tested must remain under line pressure throughout the test and until such time as regulatory agency approval to place the main in service has been received by the OWNER.

E. Following the receipt of regulatory agency approval, the CONTRACTOR will remove all sample point tubing and install a brass plug on all sample point corporation stops.

2.15 AIR AND GAS TRAPS

A. Air and gas pipes shall slope to low points and shall be provided with drip legs, shut-off valves, strainers, and traps.

B. Pipe the traps to the nearest drain.

C. Air and gas traps shall be not less than 150-lb iron body float-type, with a copper or stainless steel float.

D. Bracket, lever, and pins shall be constructed of stainless steel.

E. Drain traps shall be provided with threaded connections.

F. Air and Gas Traps Manufacturer, or approved equal

1. **Armstrong International, Inc.**

2. **Spirax Sarco, Inc.**

2.16 GLASS LINING

A. General

1. Ductile iron or steel pipe and fittings shall be glass-lined where indicated.

2. The glass lining shall be suitable for handling sewage, primary sludge, digested sludge, and scum.

3. The lining shall be smooth, continuous, and suitable for prevention of grease and foam build-up.

4. The glass lining shall be capable of withstanding thermal shock of 350 degrees F (from 430 degrees F to 80 degrees F) without crazing, blistering, or spalling.

B. The glass lining shall consist of a vitreous material to meet or exceed the following criteria:

1. unaffected by scraping with a sharp knife, simulating the effects of rodding;

2. unaffected by the continuous application of live steam from a steam generator, immediately followed by a cold water quench;

3. unaffected by an 8-percent sulfuric acid solution at 148 degrees F for a 10-minute period;

4. a minimum thickness of 10 mils by micro test;

5. spark-tested to be free of pinholes;

6. a hardness of 5 to 6 Mohs; and,

7. a density of 2.5 to 3.0 g/cu cm, measured by ASTM D 792 - Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.

C. Application

1. Cast or ductile iron pipes and fittings shall be bored or machined smooth in order to remove voids or protrusions.

2. Steel pipe shall be seamless pipe, with internal fitting welds ground smooth, slag holes ground out, re-welded, and ground smooth.

3. Interior surfaces shall be grit-blasted to white metal, and lining shall be fused onto chemically clean metal at above 1400 degrees F.

4. Welded flanges shall be factory-installed before lining.

5. Screwed flanges or cast and ductile iron pipes shall be installed after lining.

6. Pieces shall be sealed and tested prior to shipment.

7. Finish shall be subject to the ENGINEER'S approval.

D. Manufacturer, or approved equal

1. **The Pfaudler Co, Inc.**

2. **A.O. Smith Corp.**

3. **Waterworks, Mfg. Co.**

PART 3 – EXECUTION

3.1 GENERAL

A. Install piping, fittings, and appurtenances in accordance with the requirements of applicable Sections of Divisions 33 and 40.

B. Proprietary manufactured couplings shall be installed in accordance with the coupling manufacturer's recommendation.

C. Care shall be taken to insure that piping flanges, mechanical-type couplings, sleeve-type couplings, flexible connectors, and expansion joints are properly installed as follows:

1. Gasket surfaces shall be carefully cleaned and inspected prior to making up the connection.

2. Each gasket shall be centered properly on the contact surfaces.

3. Connections shall be installed to prevent inducing stress to the piping system or the equipment to which the piping is connected.

4. Contact surfaces for flanges, couplings, and piping ends shall be aligned parallel, concentric, and square to each axis at the piping connections.

5. Flange Bolts

a. Flange bolts shall be initially hand-tightened with the piping connections properly aligned.

b. Bolts shall be tightened with a torque wrench in a staggered sequence to the recommended torque for the bolt material per AWWA M-11.

6. Harness, Thrust Restraint, and Tie Rod Bolts

a. Harness, thrust restraint, and tie rod bolts used for sleeve couplings, flange coupling adapters, or flexible joints shall be tightened gradually and equally at diametrically opposite sides until snug, in order to prevent misalignment and to insure that all studs carry equal loads.

b. In order to prevent induced stress or misalignment, do not over-torque connections to adjoining pump or equipment.

7. Groove ends shall be clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove.

8. After installation, joints shall meet the indicated leakage rate.

9. Flanges shall not be deformed nor cracked.

D. Lined Piping Systems

1. The lining manufacturer shall take full responsibility for the complete, final product and its application.

2. Pipe ends and joints of lined pipes at screwed flanges shall be epoxy-coated in order to assure continuous protection.

E. Core Drilling

1. Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction in order to avoid damage to embedded raceways and reinforcing bars.

F. Cleanup

1. After completion of the WORK, cuttings, joining and wrapping materials, and other scattered debris shall be removed from the Site.

2. The entire piping system shall be handed over in a clean and functional condition.

3.2 SERVICES OF MANUFACTURER

A. Where the assistance of a manufacturer's service representative is advisable, in order to obtain perfect pipe joints, supports, or special connections, the CONTRACTOR shall furnish such assistance at no additional cost to the OWNER.

- END OF SECTION -

SECTION 40 05 07 - PIPE SUPPORTS

PART 1 – GENERAL

1.1 THE SUMMARY

A. Provide pipe supports, hangers, guides, and anchors, complete and in place, as indicated in accordance with the Contract Documents.

B. Where pipe support systems are not indicated on the Drawings, the CONTRACTOR shall design and provide the supports in accordance with this Section. The absence of pipe supports and details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing the pipe supports.

C. The provisions of this Section shall apply to piping in Divisions 33 and 40.

D. The requirements of Section 01 33 00 –Submittal Procedures apply to this Section.

E. The requirements of Section 05 50 00 – Miscellaneous Metalwork apply to this Section.

F. The requirements of Section 09 96 00 – Protective Coatings apply to this Section.

G. The CONTRACTOR shall provide supporting devices for supporting and restraining piping as indicated on the Drawings. Where pipe support devices and/or restraining details are not indicated on the Drawings, it is the CONTRACTOR'S responsibility to develop the details necessary to support and restraint the piping for a complete and functional pipe support system.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Shop Drawings

1. Submit Shop Drawings which shall include the following information:

a. Drawings of pipe supports, hangers, anchors, and guides

b. Calculations for special supports and anchors, stamped and signed by aprofessional engineer registered in the state of Florida.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Code Compliance

1. Piping systems and pipe connections to equipment shall be properly anchored and supported in order to prevent undue deflection, vibration, and dislocation due to seismic events, line pressures, pipe weight, fluid weight, liquid movement, thermal changes, vibration, probable forces applied during construction, and stresses on piping, equipment, and structures.

2. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping, except as supplemented or modified in this Section.

3. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

B. Pipe Hangers

1. Pipe hangers shall be capable of supporting the pipe in operation, allowing free expansion and contraction of the piping and preventing excessive stress on equipment.

2. Hangers shall have a means of vertical adjustment after erection.

3. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe.

4. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves shall include hydraulic shock suppressors.

5. Hanger rods shall be subjected to vertical loading only.

C. Hangers Subject to Horizontal Movements

1. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement.

2. Where horizontal pipe movement is greater than 1/2 inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold-to-hot position of the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

D. Spring-Type Hangers

1. Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping.

2. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered.

3. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate the compression of the spring.

4. Supports shall be capable of accommodating at least 4 times the maximum travel due to thermal expansion.

E. Thermal Expansion

1. Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or expansion joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely away from the anchored points.

2. Components shall be structurally suitable to withstand the imposed loads.

F. Heat Transmission

1. Supports, hangers, anchors, and guides shall be designed and insulated such that excessive heat will not be transmitted to the structure or to other equipment.

G. Riser Supports

1. Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

H. Freestanding Piping

1. Freestanding pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure.

2. Exterior, freestanding overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, or with horizontal, welded steel angles, and U-bolts or clamps securing the pipes.

I. Materials of Construction

1. Pipe support assemblies, including framing, hardware, and anchors, shall be of steel construction, galvanized after fabrication, unless otherwise indicated.

2. Submerged supports, as well as piping, conduits, and equipment in hydraulic structures within 24 inches of the water level, shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel, unless otherwise indicated.

3. Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel or FRP, unless otherwise indicated.

4. Corrosive service areas are indicated in section 40 05 00 -1.2 Definitions - Corrosive Service.

J. Point Loads

1. Meters, valves, heavy equipment, and other point loads on PVC, FRP, or other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations, in order to avoid undue pipe stresses and failures.

2. In order to avoid point loads, the supports on PVC, FRP, or other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

K. Concrete Anchors

1. Unless otherwise indicated, concrete anchors for pipe supports shall be according to the following table; consult the ENGINEER for any anchor applications not appearing on the table.

2. Anchor embedment shall be in accordance with the requirements of Section 05 50 00 – Miscellaneous Metalwork.

Pipe Support Application	Type of Concrete Anchor
New Concrete	Use embedded concrete insert anchors on a grid pattern. Use **Grinnell (Anvil International), Tolco**, or approved equal.
Existing Concrete	Use non-shrink grouted anchors, metallic type expansion anchors, or epoxy anchors. Exceptions: Metallic type expansion anchors and epoxy anchors are not permitted for pipe supports subject to vibrating loads. Epoxy anchors are not permitted where the concrete temperature is in excess of 100 deg F or higher than the limiting temperature recommended by the manufacturer. Epoxy anchors are not accepted where anchors are subject to vibration or fire.
Pipe Support Application	Type of Concrete Anchor
Vibratory Loads and High-Temperature Conditions	Use non-shrink grouted anchors

L. Noise Reduction

1. In order to reduce the transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar suitable material at each pipe support, bracket, clip, or hanger.

2.2 SUPPORT SPACING

A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads.

B. Pipe support spacing shall not exceed the maximum indicated spans.

C. For temperatures other than ambient temperatures or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations.

D. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of loading effects.

E. Steel Pipe

1. Install supports for steel pipe in accordance with the requirements of AWWA: Manual of Practice MOP-11.

2. For steel pipe sizes not indicated, the support spacing shall be designed such that the stress on the pipe does not exceed 5,000 psi.

3. Where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing indicated in the following schedule, for the indicated support condition:

PRACTICAL SPANS FOR SIMPLY SUPPORTED PIPE IN 120-DEGREE CONTACT SADDLES, FEET[1]										
Nominal Pipe Diameter, inches	Pipe Wall Thickness, inches									
	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
6	36	40	44							
8	38	42	45							
10	39	43	46							
12	40	44	47							
Nominal Pipe Diameter, inches	Pipe Wall Thickness, inches									
	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
14	40	44	47							
16	41	45	48							
18	41	46	49	52						
20	42	46	50	53						
22	42	46	51	54						
24	42	48	52	55	58	60				
26	43	48	52	56	59	61				
28	43	48	53	56	59	62				
30	43	49	53	57	60	63				
32	44	49	54	57	61	64				
34	44	49	54	58	61	64				
36	44	50	54	58	62	65	70			
38	44	50	55	59	62	65	70			
40	44	50	55	59	63	66	71			
42	44	50	55	59	63	66	72			
45		51	55	60	63	67	72			
48		51	56	60	64	67	73	78		
51		51	56	60	64	68	74	79		
54		51	56	61	65	68	74	79		
57		51	57	61	65	69	75	80		
60		51	57	61	65	69	75	80		
63		52	57	62	66	69	76	81		
66		52	57	62	66	70	76	81	86	90
72		52	58	62	66	70	77	82	87	92
78			58	62	67	71	77	83	88	93
84			58	63	67	71	78	84	89	94
90			58	63	67	71	78	84	90	94
96			58	63	68	72	79	85	90	95

[1] Reference: AWWA MOP 11, Table 7-1

F. Ductile Iron Pipe

1. Install supports for ductile iron pipe in accordance with the recommendations of the Ductile Iron Pipe Research Association (DIPRA) Design of Ductile Iron Pipe on Supports.

2. As a minimum, where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing indicated in the following schedule:

Nominal Pipe Diameter, inches	Support Configuration
ALL DIAMETERS	Two supports per pipe length or 10 feet, with one of the two supports located at a joint

G. Schedule 80 PVC and CPVC Pipe

1. Install supports for Schedule 80 PVC and CPVC pipe as indicated in the following schedule:

Nominal Pipe Size, inches	Maximum Support Spacing, feet, at 100 deg. F
½	4
3/4	4.5
1	5
1-1/4	5.5
1-1/2	5.75
2	6.25
3	7.5
4	8.25
6	10
8	11
10	12.25
12	13.25

H. Other Pipe Materials

1. Support spacing for pipe constructed of other materials shall be based on design temperature and in accordance with the pipe manufacturer's recommendations.

2.3 MANUFACTURED SUPPORTS

A. Stock Parts

1. Where not specifically indicated, designs that are generally accepted as exemplifying good engineering practice and using stock or production parts shall be utilized wherever possible.

2. Such parts shall be locally available, new, of best commercial quality, and designed and rated for the intended purpose.

B. Manufacturers, or Approved Equal

1. **Grinnell Corp. (Anvil International)**

2. **BPDI – Guard Shack APS Series**

2.4 COATING

A. Galvanizing

1. Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. Other Coatings

1. Other than stainless steel or non-ferrous supports, supports shall receive protective coatings in accordance with the requirements of Section 09 96 00 – Protective Coatings.

PART 3 – EXECUTION

3.1 INSTALLATION

A. General

1. Pipe supports, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 - Power Piping.

2. Concrete inserts for pipe hangers and supports shall be coordinated with the formwork.

B. Appearance

1. Pipe supports and hangers shall be positioned in order to produce an orderly, neat piping system.

2. Hanger rods shall be vertical, without offsets.

3. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, and without interference with other WORK.

3.2 FABRICATION

A. Quality Control

1. Pipe hangers and supports shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available.

-Fabricated supports shall be neat in appearance without sharp corners, burrs, or edges.

-END OF SECTION -

SECTION 40 05 19 – DUCTILE IRON PRESSURE PIPE

PART 1 – GENERAL

1.1 THE SUMMARY

A. The WORK covered by this section and the related sections following consists of providing all labor, equipment, material and supplies and performing all operations required to install ductile iron piping for pressure systems (e.g., lift stations and force mains), as specified and shown on the contract drawings

B. Related sections:

1. Section 01 11 00 – Summary of Work
2. Section 01 33 00 – Submittals Procedures
3. Section 03 30 00 – Cast-in-Place Concrete
4. Section 31 23 00 – Excavation and Fill
5. Section 31 23 13 – Subgrade Preparation
6. Section 31 23 33 – Trenching and Backfilling

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. AWWA C105 Polyethylene Encasement for Ductile-Iron Pipe Systems

B. AWWA C110 Ductile-Iron and Gray-Iron Fittings, 3-in through 48-in for Water

C. AWWA C111 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

D. AWWA C115 Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges

E. AWWA C116 Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.

F. AWWA C150 Thickness Design of Ductile-Iron Pipe

G. AWWA C151 Ductile-Iron Pipe, Centrifugally Cast for Water

H. AWWA C153 Ductile-Iron Compact Fittings. for Water Service

I. AWWA C600 Installation of Ductile Iron Water Mains and Their Appurtenances

J. AWWA C606 Grooved and Shouldered Joints

1.3 CONTRACTOR SUBMITTALS

A. Furnish Submittals in accordance with Section 01 33 00 – Submittal Procedures and the following supplemental requirements:

B. Shop Drawings

1. Certified dimensional drawings of valves, fittings, and appurtenances.

2. For pipe 24-inches diameter and larger, line layout and marking diagrams which indicate the specific number of each fitting and the location and the direction of each fitting in the completed line. In addition, the line layouts shall include: the pipe station and invert elevation at changes in grade or horizontal alignment; elements of curves and bends, both in horizontal and vertical alignment; and the limits of each reach of restrained joints, or of concrete encasement.

C. **Certifications:** Certified affidavit of compliance for pipe and other products or materials furnished under this Section and as specified in the referenced standards and the following supplemental requirements:

1. Physical and chemical properties.

2. Hydrostatic test reports.

D. The CONTRACTOR shall be responsible for performing and paying for sampling and testing as necessary for the certifications.

E. QUALITY ASSURANCE

1. **Tests:** Except as modified herein, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of the referenced standards as applicable.

2. The CONTRACTOR shall perform said material tests as part of the WORK. The ENGINEER shall have the right to witness testing conducted by the CONTRACTOR; provided, that the CONTRACTOR's schedule is not delayed for the convenience of the ENGINEER.

3. In addition to those tests specifically required, the ENGINEER may request additional samples of any material including lining and coating samples for testing by the OWNER. The additional samples shall be furnished as a part of the WORK.

4. **Inspection:** Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of the referenced standards, as supplemented by the requirements herein. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing starting date not less than 14 Days prior to the start of any phase of the pipe manufacture.

5. During the manufacture of the pipe, the ENGINEER shall be given access to areas where manufacturing is in process and shall be permitted to make inspections necessary to confirm compliance with the Specifications.

6. Three certified records of the tests made by the manufacturer or by a reliable commercial laboratory shall be submitted with each shipment of pipe of any type used for force mains.

PART 2 – PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

A. Lined and polyethylene-wrapped ductile iron pipe shall conform to AWWA C151 and C105, subject to the supplemental requirements in this Section. The pipe shall be of the diameter and class indicated, shall be provided complete with rubber gaskets, specials, and fittings as required under the Contract Documents.

B. **Markings:** The CONTRACTOR shall legibly mark specials 24-inches diameter and larger in accordance with the laying schedule and marking diagram. Each fitting shall be marked at each end with top field centerline.

C. **Handling and Storage:** The pipe shall be handled as a minimum at the 1/3 points by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment that might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be supported on padded skids, sand or earth berms free of rock exceeding 3-inches diameter, sand bags, or suitable means so that the coating will not be damaged. The pipe shall not be rolled and shall be secured to prevent accidental rolling

D. Bonded dielectric-coated pipe shall have the following additional requirements:

1. It shall be the responsibility of the CONTRACTOR to prevent damage of the coating that might be caused by handling and/or storage of the completed pipe at low temperature.

E. **Laying Lengths:** Nominal pipe laying lengths shall be 20-feet.

F. **Finish:** The pipe shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.

G. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing on the Drawings. The locations of correction pieces and closure assemblies are indicated. Any change in location or number of said items shall only be as accepted by the ENGINEER.

2.2 MATERIALS

A. Design of Pipe

1. The pipe shall be designed, manufactured, tested, inspected, and marked according to AWWA C150 and C 151 except where modified by this Section.

2. Potable Water transmission Piping: Unless otherwise indicated DIP used for potable water transmission systems shall meet the following requirements:

a. For potable water transmission pipe 18" in diameter and smaller: provide Class 350 special thickness 50 conforming to ANSI A 21.51/AWWA C-151

b. For potable water transmission pipe larger than 18" in diameter: provide Class 250, special thickness class 50, conforming to ANSI A 21.51/AWWA C-151.

3. **Pipe Dimensions:** The pipe shall be of the diameter and class indicated.

4. **Fitting Dimensions:** The fittings shall be of the diameter and class indicated.

5. **Joint Design:** Ductile iron pipe and fittings for buried pressure service shall be furnished with restrained joints, unless otherwise indicated.. Above ground ductile iron pipe and fittings joints shall be as indicated. Flanged joints or grooved and shouldered joints shall be furnished where required.

   a. Mechanical and push-on joints shall conform to AWWA C111.

   b. Flanged joints shall conform to AWWA C115. Where threaded flanges are provided, the pipe wall thickness under the cut threads shall not be less than the calculated net thickness required for the pressure class of the pipe.

6. Joint restraining devices that impart point loads and/or wedging action on the pipe wall as a means of joint restraint shall not be allowed unless there are no other options for joint restraint available. Under such circumstances, the CONTRACTOR may propose such devices provided the following conditions are met and the request is made as a substitution:

   a. A formal request for substitution is submitted stating the locations where the devices are intended to be used and a statement from the device manufacturer and the pipe manufacturer that the proposed device is appropriate for the intended installation and is rated at least for the class of the pipe being supplied.

   b. A statement from the pipe manufacturer is provided accepting the use of the retaining devices and indicating that the use of such devices will in no way affect the warranty of the pipe and/or the performance of the pipe.

   c. The manufacturer of the device and the pipe manufacturer jointly provide instruction on the proper installation of the device to the personnel installing the units and provide certification to the OWNER that the installers are adequately trained in the installation of the units and that warranties are in full affect for the project.

7. Grooved and Shouldered Joints shall meet the requirements of mechanical-type couplings in accordance with Section 40 05 00 – Piping, General and conform to AWWA C606.

B. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.

C. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated.

D. Lining:

1. All ductile iron pipe and fittings shall have a ceramic epoxy lining on the interior and a bituminous coating on the exterior except for 6" back from the spigot end. The bituminous coating shall not be applied to the first 6" of the exterior of the spigot ends. All pipe and fittings shall be delivered to the application facility without asphalt, cement lining, or any other lining on the interior surface. Because removal of old linings may not be possible, the intent of this specification is that the entire interior of the pipe and fittings shall be as cast without ever having been lined with any substance prior to the application of the specified lining. Any pipe or fittings furnished for this project must not have been lined prior to the awarding of the contract for this project.

   a. Lining Material: The material used for the lining shall be a two component amine cured epoxy of at least 87% solids. **Protecto 401** by Induron, Birmingham, Alabama or **Permite 9043, Type II Glass Filled Epoxy** by Permite Corporation, Atlanta, Georgia are the Standards of Quality. The following test requirements are certified by the material supplier, and a history of satisfactory performance for the material in the service required and upon the surface specified is proven. The following are the minimum requirements to be met:

      1) A permeability rating of zero permeance when a film of at least 40 mils is tested according to ASTM D1653-72 (reapproved 1979) or a permeability rating of 0.0 perms when measured using Method A of ASTM E96-66, procedure A with a test duration of 42 days.

      2) The material shall contain at least 20% by volume of ceramic quartz pigment in the dried film.

      3) The following test must be run on ductile iron panels with the results certified by the lining material supplier of the material being submitted.

Test	Rating/Method
Direct Impact	ASTM D-2794
3% Sulfuric Acid Immersion @ 120 Deg F	ASTM D-714-56 (1974)
25% Sodium Hydroxide Immersion @ 140 Deg F	ASTM D-714-56 (1974)
Deionized Water Immersion @ 160 Deg F	ASTM D-714-56 (1974)
Moisture and Ultraviolet Light Cycle. 8 hrs light/4 hrs, 100% humidity	ASTM G-5377

2. Application of Lining:

   a. The lining shall be applied by a competent firm with at least a five year history of applying linings to the interior of ductile pipe and fittings.

1) Surface Preparation: Prior to abrasive blasting the entire area which will receive the protective compound shall be inspected for oil, grease, etc. Any areas where oil, grease, or any substance which can be removed by solvent is present shall be solvent cleaned using the guidelines outlined in SSPC-1 Solvent Cleaning. After the surface has been made free of grease, oil or other substances, all area which are to receive the protective compounds shall be abrasive blasted using compressed air nozzles with sand or grit abrasive media. The blast media shall strike the surface at a minimum angle of 45 degrees. The entire surface to be lined shall be struck with the blast media so that all rust, loose oxides, etc., are removed from the surface. Only slight stains and specks of tightly adhering oxides may be left on the surface. Any area where rust reappears before coating must be reblasted to remove all rust.

2) Lining: After surface preparation and within 8 hours of surface preparation the barrel of the pipe from the inside shoulder of the gasket groove to the end of the interior spigot shall receive a minimum coating of 40 mils dry film thickness of the protective lining. If flange fittings or pipe are included in the project the linings must not be used on the face of the flange; however, full face gaskets must be used to protect the ends of the pipe. All fittings shall be lined with a minimum of 40 mils of the protective lining. Push-on type fittings shall be lined from the gasket groove to the gasket groove. The 40 mils system shall not be applied in the gasket grooves.

3) Coating of Gasket Groove and Spigot Ends: Due to the tolerances involved, the gasket groove and spigot end up to 6" back from the end of the spigot end must be coated with a minimum of 10 mils dry of **Protecto Joint Compound**. This coating shall be applied by brush to insure coverage. Care should be taken that the coating is smooth without excess buildup in the gasket groove or on the spigot end. All materials for the gasket groove and spigot end shall be applied after the application of the lining.

4) Number of Coats: The number of coats of lining material applied shall be as recommended by the lining manufacturer. However, in no case shall the material be applied above the dry thickness per coat recommended by the lining manufacturer in printed literature. The time between coats shall never exceed that time recommended by the lining material manufacturer. No material shall be used for lining which cannot be recoated with itself without roughening of the surface after 4 hours cure @ 100 Deg F. If at any time the lining must be recoated beyond the lining material manufacturer's recommended recoat time, the surface of the existing lining shall be roughened sufficiently to prevent delamination between coats.

3. Lining Inspection

a. All pipe shall be checked for thickness using a magnetic film thickness gauge. The thickness testing shall be done using the method outlined in SSPC-PA-2 film thickness testing.

b. The barrel of all pipe and fittings shall be pinhole detected with a nondestructive 2,500 volt pinhole test.

c. Each pipe joint and fitting shall be marked with the date of application of the lining system and with its numerical sequence of application on that date.

4. Lining Certification

a. The pipe or fitting manufacturer must supply a certificate attesting to the fact that the Applicator met the requirements of this specification, that the material used was as specified, and that the material was applied as required by the specification.

5. Lining Repair

a. All pinholes and damaged lined areas shall be repaired in accordance with written repair procedure furnished by the manufacturer of the lining material so that the repaired area is equal in performance to the undamaged lined areas.

E. Coating

1. The exterior of the pipe shall receive a bituminous coating approximately 1 mil thick in accordance with ANSI A21.51.

2. See Section 09 96 00 – Protective Coatings for coating requirements.

3. Polyethylene Sleeve: Sleeves shall conform to the requirements of AWWA C105, CONTRACTOR's choice between tubular 8-mil thick linear low-density film or 4-mil thick high-density cross-laminated film. Color shall be black.

a. Buried ductile iron pipe shall be polyethylene encased in accordance with the requirements of AWWA C105, CONTRACTOR's choice between Method A or Method B.

PART 3 – EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall inspect each pipe and fitting prior to installation to insure that there are no damaged portions of the pipe. Pipe damaged prior to Substantial Completion shall be repaired or replaced by the CONTRACTOR.

B. Before placement of pipe in the trench, each pipe or fitting shall be thoroughly cleaned of any foreign substance which may have collected thereon and shall be kept clean at all times thereafter. For this purpose, the openings of pipes and fittings in the trench shall be closed during any interruption to the WORK.

C. **Pipe Laying:** The pipe shall be installed in accordance with AWWA C600.

D. Pipe shall be laid directly on the bedding material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation shall be made as needed outside the normal trench

section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

E. Each section of pipe 24-inches diameter and larger shall be laid in the order and position shown on the laying schedule. Each section shall be laid to the line and grade, within approximately one-inch plus or minus.

F. Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the ENGINEER may change the alignment and/or the grades. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings. However, in no case shall the deflection in the joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint.

G. Except for short runs that may be permitted by the ENGINEER, pipes shall be laid uphill on grades exceeding 10 percent. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. Bends shall be properly installed as indicated.

H. **Cold Weather Protection:** No pipe shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation before backfilling occurs.

I. **Pipe and Specials Protection:** The openings of pipe and specials shall be protected with suitable bulkheads to prevent unauthorized access by persons, animals, water, or any undesirable substance. At all times, means shall be provided to prevent the pipe from floating.

J. **Pipe Cleanup:** As pipe laying progresses, the CONTRACTOR shall keep the pipe interior free of debris. The CONTRACTOR shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying and shall perform any necessary interior repairs prior to testing and disinfecting the completed pipeline.

3.2 MISCELLANEOUS INSTALLATION CONDITIONS:

A. **Pump Station Piping:** Piping shall be installed as shown on the drawings. Flanged joints shall be made up tight, care being taken to prevent undue strain upon pump nozzles, valves, and other pieces of equipment. Piping within structures shall be adequately supported from floors, walls, or ceilings. Supports from the floor shall be by approved saddle stands or suitable concrete piers as shown or approved by the ENGINEER. Pipe saddles shall be shaped to fit the pipe with which they will be used and shall be capable of screw adjustment. Concrete piers shall conform accurately to the bottom one third to one half of the pipe. Piping along walls shall be supported by approved wall brackets with attached pipe rolls or saddles or by wall brackets with adjustable hanger rods. For piping supported from above, approved rod hangers of a type capable of screw adjustment after erection of the piping and with suitable adjustable concrete inserts or beam clamps shall be used. Supports shall be located where shown, or specified, and in no case shall they exceed eight feet on centers.

B. **Sewage Force Mains:**

1. Where it is necessary to cut the pipe to place special castings, care must be taken not to crack the pipe and to cut straight and true around it. All joints shall be watertight and any leaks or defects discovered shall be immediately repaired to the satisfaction of the ENGINEER. Any pipe which has been disturbed after being laid shall be taken up, the joints cleaned, and the pipe properly re-laid. Damaged or unsound pipe or fittings will be rejected. Before jointing the pipe, all lumps, blisters, excess coating material and any dirt or sand shall be removed from the bell and spigot ends of pipes. Any superfluous material inside the pipe shall be removed after joints are made.

2. Ductile iron pipe and fittings shall be internally restrained in all such areas by means of restrained or harnessed joints. Design computations for all locations of restrained or harnessed joints shall be submitted to the ENGINEER prior to fabrication.

3. All in-line valves shall be similarly restrained by the adjoining pipeline, on both sides, with no allowance for downstream thrust resistance. Ends of pipe joining in line valves shall be provided with restrained joint ends compatible with the valves furnished. Where necessary to deflect the pipe from a straight line at joints, the deflection shall not exceed 75% or as recommended by the MANUFACTURER. If the specified or required alignment requires deflections in excess of those recommended, the CONTRACTOR shall either provide special bends as approved by the ENGINEER, or a sufficient number of shorter lengths of pipe to provide angular deflections within the limits set forth by the MANUFACTURER. All force mains shall be installed with a 36-inch minimum cover.

C. **Pipe Supports:** Where there is no adequate natural foundation upon which to construct a pipe bed, the pipe shall be constructed on a prepared stabilized subgrade, rock bedding, or wood supports.

D. Unsuitable subgrade materials shall be replaced or stabilized as described in Section 31 23 13 – Subgrade Preparation. Gravel or graded limerock may be used for pipe bedding where suitable material is not available at the site and in accordance with the subparagraphs under Section 31 23 00 – Excavation and Fill. Such material will be paid for under the bid item for same only when ordered in writing by the ENGINEER. Wood supports, if required, will be authorized by change order only.

E. **Sleeves:** Cast iron pipe sleeves or wall pipe shall be placed where shown on the drawings for piping through concrete or masonry walls. Wall sleeves shall be standard weight, Class D, as required for the pipe sizes shown on the drawings. Wall thimbles shall be cast iron square flange with round openings. Size of thimbles shall be as shown on the drawings.

F. **Harnessing:** Where harnessing is shown on the drawings or approved by the ENGINEER, all harnessing rods, clamps, bolts, and nuts shall be coated after assembly. The coating shall be a coal tar or asphalt base bituminous coating approved by the ENGINEER and applied to at least a 4 mil dry thickness.

G. **Canal Crossings:**

1. The OWNER will obtain the necessary construction permits from the governing authorities. The CONTRACTOR shall not begin WORK on any canal or ditch crossing until he receives a copy of the approved permit. The WORK shall be subject to any additional requirements of the governing authority.

2. Canal crossing shall be of two types, major and regular. Regular crossings shall be installed using push on or mechanical joint pipe, conforming to the specifications for pipe and fittings in Section 40 05 19 - Ductile Iron Process Pipe. Fittings at crossings shall be thrust blocked, or harnessed, except where thrust blocking is not practical, harnessing or other restrained type joint shall be used.

3. Major crossings shall be installed using ball joint pipe conforming to the specifications for major canal crossings as specified herein.

H. **Highway Crossings:** All pipe under State highways shall be installed in accord with the requirements of the State Department of Transportation. The highway department involved will govern the method and materials of construction. The OWNER shall obtain the necessary permits to enter into said highway and the CONTRACTOR will be responsible for any and all expense the highway department incurs in protecting its highway while pipes are being installed, as well as being held responsible for any damage to the highway itself. The CONTRACTOR shall secure from the highway department the necessary information regarding proper bracing, sheeting, shoring and other required protection of the highway and traffic during the construction operation. Where an open cut is permissible in crossing a highway instead of boring, the CONTRACTOR shall make the necessary provisions for handling traffic and replacing the road bed and surface as required by the applicable governing authority. Pavement restoration shall be in accordance with Section 31 23 33 - Trenching and Backfilling and Section 31 23 13 – Subgrade Preparation.

I. **Connections to Existing Force Mains:** Where connections are required between new work and existing force mains, the connections shall be made in a thorough and workman like manner using proper specials and fittings to suit the actual conditions. In a case a connection is made to an existing fitting in the line, the CONTRACTOR shall schedule his/her work so that digging and locating the existing fittings can be completed prior to starting trench work on the line. Cut-ins into lines shall be done at a time approved by the OWNER's representative. The CONTRACTOR shall verify the dimensions of all pipe before ordering special fittings and couplings.

J. **Flexible Coupling:** Flexible coupling shall be of a gasketed, sleeve type. Each coupling shall consist of a steel middle ring, two steel followers, two rubber compounded wedge section gaskets and sufficient galvanized track, head steel bolts to properly compress the gaskets. Coupling shall be of the type to match piping in which installed. Couplings shall be Style 38 as manufactured by Dresser Manufacturing Division of Dresser Industries, Smith Blair Type 411, or approved equal.

K. **Unions and Flanges:** Unions and flanges are not, in every case, shown on the drawings, but are to be provided where necessary and adjacent to all equipment installed or provided for under this Contract. Ground joint unions shall be provided on and pipe sizes up to and including 1-1/2 inches. Flanged unions shall be used on all pipes larger than 1-1/2 inches. Use malleable iron on steel piping, black or galvanized as specified for piping. Unions in copper piping shall be brass.

3.3 FIELD ASSEMBLY

A. Rubber Gasketed Joints

1. Immediately before jointing pipe, the bell end of the pipe shall be thoroughly cleaned, and a clean rubber gasket shall be placed in the bell groove. The spigot end of the pipe and the inside surface of the gasket shall be carefully cleaned and lubricated. The lubricant shall be suitable for lubricating the parts of the joint for assembly and be a compound listed as in compliance with NSF Standard 61. The lubricant shall be nontoxic, shall not support the growth of bacteria, and shall have no deleterious effects on the gasket material. The lubricant shall not impart taste or odor to water in the pipe. The spigot end of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted.

3.4 PREPARATION

A. Protection:

1. **Protection of Appurtenances:** Where pipe is encased in polyethylene sleeves, buried appurtenances shall be encased in polyethylene.

2. **Installation of Valves:** Valves shall be handled in a manner to prevent any injury or damage to any part of the valve. Joints shall be thoroughly cleaned and prepared prior to installation. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to insure proper operation. Valves shall be installed so that the valve stems are plumb and in the location indicated.

3.5 FIELD QUALITY CONTROL

A. Site Tests:

1. **Tests:** The CONTRACTOR shall furnish and install suitable temporary testing plugs or caps for the pipe, all necessary pressure pumps, hose, pipe connections, meters, gauges and other similar equipment, and all labor required, all without additional compensation for conducting pressure tests of the new pipe and fittings. The OWNER may, at his/her own choice, furnish a meter and a pressure gauge for use in conducting these tests.

2. Pressure testing shall be as specified in Section 01 74 30 – Pressure Pipe Testing and Disinfection.

END OF SECTION

SECTION 40 60 00– PROCESS CONTROL AND ENTERPRISE MANAGEMENT SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR, through the use of the SYSTEM INTEGRATOR and qualified electrical installers, shall provide the PLC-based Supervisory Control and Data Acquisition system (SCADA) complete and operable, in accordance with the CONTRACT Documents.

B. SYSTEM INTEGRATOR: shall be responsible for selecting, sizing, and providing the correct and necessary type and quantity of hardware for the entire SCADA System and for each PLC. The necessary hardware and software shall include but not limited to servers, workstations, network hardware, PLC input/output (I/O) modules, interconnecting cables, accessories, communication ports, adapters and cards, and all appurtenances for proper operation of the SCADA System and to meet the functional requirements described in these specifications, and as shown on the system architecture diagram or network diagram. The SYSTEM INTEGRATOR shall be responsible for the interface to existing systems or those furnished by others. The SYSTEM INTEGRATOR shall also provide the latest version of software to enable the programming and the integration of the SCADA System.

C. The SYSTEM INTEGRATOR shall be the integrator of all hardware and all databases, data acquisition, and control software. Additionally, the SYSTEM INTEGRATOR shall be responsible for the application programming of the SCADA System Graphics, Databases, PLC Logic per the Control Strategies and other Sections of the Specifications.

D. SYSTEM INTEGRATOR SCOPE: The CONTRACTOR and SYSTEM INTEGRATOR are responsible for all aspects of the supply, configuration, installation, testing, startup and warranty of the SCADA System. The SCADA System includes PLC's, OIT displays, local panels, field instrumentation, Workstations, Servers, communication equipment, and communication segments, software, CCTV system and interconnecting cable media.

E. The exact contractual relationship and scope definition shall be established exclusively between the CONTRACTOR and the SYSTEM INTEGRATOR. It is the intent of these specifications that the SYSTEM INTEGRATOR, under the direction of the CONTRACTOR, shall assume full responsibility for the following, as a minimum:

1. Procurement of all hardware and software required to conform to these specifications.

2. Design and submit SCADA hardware, software, and spare parts submittals.

3. Design and submit SCADA training for factory and on-site training.

4. Perform all required SCADA tests, adjustments, and calibrations in conjunction with the CONTRACTOR.

5. Furnish qualified labor to supervise SCADA installation and to perform start-up activities in conjunction with the CONTRACTOR.

6. Furnish qualified certified instructors to provide SCADA instruction and training.

7. Furnish all required SCADA tools, test equipment, spare parts, supplies, operations and maintenance manuals, reproducible record drawings, and program listings as specified herein.

F. SCADA Configuration: The SCADA shall consist of PLC's, communication modules, HMI, OIT and all required equipment and peripherals as shown on the CONTRACT Drawings and as described in these specifications, and as required to meet the functional intent of the specifications

G. The SYSTEM INTEGRATOR shall be responsible for the interface to systems furnished by others and for the interface to existing equipment as shown on the CONTRACT Drawings.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Section 40 90 00 – Process Control and Instrumentation

B. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems

C. Division 26 – Electrical

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: SCADA submittals shall be in accordance with the applicable requirements of Section 40 90 00 – Process Control and Instrumentation. SCADA submittals shall, however, be made separately from other process control and instrumentation system submittals.

B. Hardware Submittals: The SCADA hardware submittal shall be a single submittal which includes at least the following:

1. A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tags.

2. Complete grounding requirements for the entire SCADA including any requirements for SCADA communication networks and control room equipment.

3. Requirements for physical separation between SCADA components and 120 volt, 480 volt elements.

4. Substation and Control Room floor plans drawn to scale. Drawings shall be drawn in a 1/2 inch = 1 foot scale.

5. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.

A complete set of SCADA diagrams which depict:

a. All PLC's, area control stations, printers, communication and network devices, and communication links.

b. All cables required to support the communication requirements. A separate diagram shall be submitted for each component fully annotated with conduit size and number associated with the power source.

c. Data sheets shall be included for each SCADA component together with a technical product brochure or bulletin. These data sheets shall show the component name as used within the CONTRACT Documents, the manufacturer's model number or other identifying product designation, the project tag number, the project system of which it is a part, the Site to which it applies, the input and output characteristics, the requirements for electric power, the ambient operating condition requirements, and details on materials of construction.

6. Complete and detailed bills of materials: A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component of the SCADA system. Bills of material shall include all items within an enclosure.

7. Site-specific arrangement and construction drawings for all equipment cabinets, including dimensions identification of all components, preparation and finish data, nameplates, and the like. Drawings shall be scaled and show the position of the equipment on its intended installation location. Drawings must show a scaled representation of the placement of all equipment and its spatial relationship to all other equipment located in the abutting and adjoining areas. All acquired access and clearances associated with the equipment must be shown with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

8. Calibration, adjustment, and test details for all SCADA components.

C. Owner's Manuals: General requirements for Owner's Manuals are as described in Section 40 60 00 - Process Control and Enterprise Management Systems. The following items shall also be included in the SCADA manual:

1. A documented PLC program listing including the I/O list and housing configuration for each PLC, a memory usage report for each PLC, and a register layout list for each PLC.

2. Each Server and Workstation configuration including installed software, patches, parameters, etc.

3. Operation and maintenance manuals for the PLCs, the network hardware, and all other SCADA hardware.

D. System Test Procedures

1. System test procedures shall be developed by the SYSTEM INTEGRATOR in accordance with the requirements for system testing indicated below, and shall be submitted to the ENGINEER for review. An approved submittal shall be required prior to the commencement of system testing.

2. The loop test shall be point-point from the field device to the SCADA area control stations HMI screen. Testing shall reflect the requirements of Section 40 60 00 - Process Control and Enterprise Management Systems.

E. Factory Test Procedure: The SYSTEM INTEGRATOR shall prepare and submit a factory test procedure which incorporates test sequences, test forms, and an estimated test duration which complies with the requirements of the factory test specified herein.

1.4 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The CONTRACTOR/SYSTEM INTEGRATOR shall arrange for visits by, and services of, technical field representatives of the PLC software manufacturers for installation certification, system testing, training, and start-up. These services shall be part of the WORK.

1.5 STORAGE AND HANDLING

A. All equipment and materials delivered to the Site shall be stored in a location which shall not interfere with the operations of the OWNER's personnel or interfere with construction. Storage and handling shall be performed in a manner which shall afford maximum protection to the equipment and materials. It is the CONTRACTOR's responsibility to assure proper handling and on-site storage.

1.6 SPECIAL WARRANTY REQUIREMENTS

A. Special warranty requirements shall be in accordance with the applicable requirements of Section 40 60 00 - Process Control and Enterprise Management Systems. The following additional warranty requirements apply specifically to the SCADA System.

B. The complete SCADA System (and associated software) included therein shall be guaranteed to meet or exceed the design requirements set forth in the CONTRACT Documents.

C. Equipment, software, and materials which do not achieve design requirements after installation shall be replaced or modified by the SYSTEM INTEGRATOR to attain compliance. The cost for doing so shall be the CONTRACTOR's responsibility. Following replacement or modification, the CONTRACTOR shall retest the system and perform any additional procedures needed to place the complete SCADA in satisfactory operation and attain design compliance approval from the ENGINEER.

D. The CONTRACTOR warrants the materials and workmanship used for the SCADA equipment and materials and further guarantees the materials and workmanship used for any equipment and materials produced and furnished hereunder as a part of the Work to be as required and agreed upon, free from injurious defects, and in all respects satisfactory for the service required.

E. The CONTRACTOR warrants/guarantees the satisfactory performance of the equipment and materials under operating conditions for a period of two years after the date of final acceptance of the entire SCADA (i.e. completion of all contractual items including a successful full system-wide 30 day performance test as specified in Part 3). In the event that tests and inspections disclose latent defects or failure to meet the specified requirements, the SYSTEM INTEGRATOR upon notification by the OWNER shall proceed at once to correct or repair any such defects or non-conformance or to furnish, at the delivery point named in the CONTRACT Documents, such new equipment or parts as may be necessary for conformity to the requirements, and shall receive no additional compensation therefore. In case of any required repairs or other corrective or remedial work covered under warranty, the warranties on all such corrections, repairs, new equipment, or parts shall be extended for an additional 24 months from the date of final acceptance or 12 months from the date of completion of any such corrections, repairs, new equipment, or parts, whichever date is later. If the OWNER performs repair, the CONTRACTOR shall reimburse the OWNER for all costs incurred in the removal of the defective material and installation of the replacement.

1.7 GUARANTEE

A. The CONTRACTOR shall guarantee the performance of all the new PLCs and the programming software for them as specified elsewhere in the Contract Documents.

B. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.

C. Guarantee and special corrections of defects and software upgrade requirements and warrantee shall be in accordance with Section Section 40 60 00 - Process Control and Enterprise Management Systems.

1.8 LICENSES

A. The CONTRACTOR shall provide and register the OWNER with all user software and hardware licenses. Additional contract, agreements and licenses requirements shall be in accordance with Section 40 60 00 - Process Control and Enterprise Management Systems.

PART 2 – PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

A. The requirements of Section 40 90 00 Process Control and Instrumentation apply to this Section.

B. All materials and all SCADA equipment furnished under this CONTRACT shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.

D. All PLC and OIT hardware, components, circuit boards, and modules shall be furnished with conformal coating where offered by the manufacturer. The conformal coating is required to extend the life of the components and circuitry by protecting against moisture, dust, chemicals, temperature extremes and airborne contaminants.

C. For digital output modules with a continuous load equal to or greater than one amp, an interposing relay shall be installed.

D. Hardware Commonality: Where there is more than one item of similar equipment being furnished all such similar equipment shall be the product of a singular manufacturer.

E. SCADA Growth Provisions:

1. The SCADA growth provisions are divided into three sections:

a. Future expansion capacity (100%).

b. Installed Spare I/O points (20%)

c. Panel, cabinet, communication rack Spare Space Allocation (25%).

2. Future expansion capacity: the SCADA firmware and hardware, including PLC processor memory, workstation, Client/Server and HMI Client/Server hard disc space, and Local Area Network (LAN) gear, shall have the capacity to accommodate a future expansion of 50% in the number of I/O points as shown in the CONTRACT Documents and listed in Appendix A – IO List. This requirement is in regards to the SCADA System's capacity to accommodate a growth of 100% future HMI displays, 100% future PLC I/O racks, 100% future PLC logic and 100% future LAN connections.

3. Installed Spare PLC I/O points: All hardware and resources, including PLC I/O cards, wiring, terminals, fuses, database and configuration shall be furnished such that at least 20% additional I/O points can be implemented without any additional cost to the OWNER. The Installed Spare I/O shall be 20% of the total I/O installed per PLC cabinet, e.g. each PLC enclosure, RIO enclosure, or Flex I/O block shall have 20% Installed Spare I/O.

4. Panels, cabinets, communication racks Spare Space Allocation: the CONTRACTOR shall provide 25% spare space for hardware including; terminal blocks, fused terminal blocks, circuit breakers, ground provisions, wiring, rack mount shelves, etc.

2.2 SCADA ENCLOSURES

A. Each PLC and its corresponding I/O modules, power supply module(s), communication interface device(s), and peripheral equipment shall be mounted inside suitable enclosures. All I/O wiring from the field to the I/O modules shall be terminated on terminal blocks in the enclosure. Refer to Contract Specification 40 92 00 - Control Panels.

B. SCADA enclosures shall be provided in accordance with Specification 40 90 20 - Control Panels.

2.3 PROGRAMMABLE LOGIC CONTROLLER (PLC) HARDWARE

A. The SYSTEM INTEGRATOR shall furnish all necessary hardware, software, interconnecting cables, all accessories, and all appurtenances as indicated herein or as required for proper operation of the PLC.

B. All components that are common to the PLCs shall be of the same manufacturer and family of PLCs. All the PLCs shall have the same components manufacturer (e.g. processor, memory, chassis style, I/O cards, etc.). Special minor interface hardware not provided by the PLC manufacturer can be a product by the manufacture's approved third party.

C. The SYSTEM INTEGRATOR shall size each PLC in accordance with the I/O list.

D. The PLCs shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:

1. Ambient temperature range: 0°C through 60°C

2. Thermal shock: 1.0° (1.8°F) per minute maximum

3. Relative humidity: 95 percent maximum non-condensing

E. Construction: The PLC central processing unit (CPU) shall be modular unit which shall contain the operating logic. The input/output (I/O) modules shall also be modular and interface directly with the CPU through a back common panel or by a special cable if I/O expansion is required. The PLC shall provide a means for mounting the chassis in a standard cabinet or 19-inch rack. The PLC shall be capable of operating in a hostile industrial environment (i.e., heat, electrical transients, RFI, vibration, etc.) without fans, air conditioning, or electrical filtering and be designed to provide high reliability specifically in this process application.

F. Design

1. General

a. The PLC shall be of modular, field expandable design allowing the system to be tailored to this process control application. The capability shall exist to allow for expansion of the system by the addition of hardware and/or user software. The PLC shall be provided with I/O (input/output) modules and with sufficient memory, power and appropriate cables to be able to interface with new and existing field devices, necessary to function as a complete and operable PLC system.

b. Logic functions must perform in a given application shall be programmed into the PLC memory. All equipment shall be capable of tolerating and capable of riding through a power interruption of 8 milliseconds or less without interruption of normal operation and communication.

c. It is the intent of these specifications to provide PLCs which can be easily expanded and configured. Therefore, all changes in system architecture, expansion of I/Os, modification to and implementation of control strategies shall be easily done on-site

d. The PLC shall be capable of communicating with remote I/O racks or other PLCs via fiber optic cable up to 0,000 cable feet or copper cable up to 300 cable feet from the processor without requiring additional communications hardware except for fiber-to-copper modules.

G. PLC Processors – Control Logix

1. PLCs shall be used for the main facility PLCs.

2. Program Memory Size: 32 MBytes minimum.

3. Memory Type: Program and data in non-volatile flash-backed RAM. Operating system in non-volatile firmware. Battery life for 1756-BATA, power off, is a minimum of 133 days @ 25°C. The lithium battery (1756-BA2) shall maintain memory for a minimum of 20 months (up to three power cycles a day at a maximum temperature of 40°C.) Battery life with no power applied is eight months.

4. I/O Capacity: 128,000 discrete I/O (any mix of inputs and outputs) or 4000 analog I/O, maximum.

5. Up to 250 connections (nodes). Up to 64 connections over ControlNet (maximum of 48 recommended). Up to 128 connections over Ethernet / IP.

6. Bit execution time less than 0.15 microseconds.

7. Installation Location: Left-most slot of the I/O chassis (typical).

8. Diagnostics:

   a. Standard, self-diagnostic routines shall be provided to determine proper hardware and software operation.

   b. Diagnostic LEDs shall be provided on the processor front panel to indicate the following:

      1) Processor running.

      2) Processor fault.

      3) Battery low.

      4) Forced I/O.

      5) Communications active.

      6) Communications error.

9. Communications: The PLC processor shall be equipped with on-board communications ports for the following:

   a. USB port.

10. Instruction Set:

   a. The PLC shall be equipped with the following instructions as a minimum:

      1) Relay-type logic functions including normally open contacts, normally closed contacts, and output coils.

      2) Timers: On delay, off delay, and retentive.

      3) Counters: Up, down.

      4) Math functions including integer and floating point, add, subtract, multiply, divide, and square root.

      5) Data transfer instructions.

      6) Logical AND, NOT, OR, XOR instructions.

      7) Compare Instructions: Equal to, greater than, less than.

      8) Proportional - Integral - Derivative control instruction.

      9) Add-On Instructions

   b. The PLC shall support branching functions to allow any combination of series or parallel instructions.

   c. The PLC shall support the use of subroutines where appropriate.

11. Programming software: IEC 61131-6 compliant. Available languages:

    a. Ladder logic

    b. Function block diagram (FBD)

    c. Sequential function charts (SFC)

    d. Structured text

12. Online programming including run-time editing

H. Data Communications: Each programmable logic controller shall be equipped with, or have access via linked backplane to the following communication options as required (and in the quantities indicated) on the Network Block Diagrams:

1. Dual port (RJ45) EtherNet/I/P card.

2. One RS-232-C serial programming port.

3. ControlNet Adapter module.

4. ProSoft Modbus RS-485 modules – for Modbus RTU and/or Modbus/TCP communications as indicated.

5. ProSoft Profibus DP master modules.

6. One USB Port.

I. Power Supplies:

1. Each PLC processor and I/O chassis shall include a power supply. The power supply shall be mounted on the left end of the I/O chassis and plug directly into the backplane.

2. Input Voltage: 120 VAC, 60 Hz.

3. Output Current: 13 A at 5 VDC.

4. Provide all cabling as required.

5. Provide power supply to power field devices that require 24 VDC. Mount alongside I/O chassis.

6. Input Voltage: 120 VAC, 60 Hz

7. Output Current: Sized for loads at 24 VDC

8. Provide all cabling as required.

J. I/O Chassis:

1. Type: I/O chassis designed to house the PLC processor, network communication interface modules (including Ethernet, ControlNet, DeviceNet, and universal remote I/O communication modules, etc.), and the I/O modules. The chassis shall be sub-panel mounted.

2. Provide all required signal and power cables between I/O chassis and power supplies, as required.

K. I/O Modules:

1. Provide I/O module-ready cables with a pre-wired Removable Terminal Blocks (RTB) on one end to plug onto the front of a Bulletin 1756 I/O modules and individually colored #18 AWG conductors on the other end. The number of conductors (20 or 40) to be established per I/O module type. The I/O module-ready cables consist of pre-wired connections at the I/O module end and provide termination on a standard terminal block for field wire connection.

2. Available Types: The types of I/O modules available for use with the PLC system shall be as required by the CONTRACT Documents. Provide screw-clamp removable terminal blocks for all I/O cards. The following types of manufacturer standard I/O modules shall be available:

   a. Sixteen point individually isolated discrete input modules which accept an input of 120 VAC, 60 Hz.

   b. Sixteen point isolated output modules. Each output point shall be independently fused and individual blown-fuse indication for each point. Isolated outputs shall have a current capacity of 2 amps at 120 VAC.

   c. Eight point isolated analog input modules (16 bit minimum resolution) which accept an input of 4-20mA DC and read the HART signal.

   d. Eight point voltage or current analog output modules (16 bit minimum resolution) selectable for ±10.4V, 0-20mA or 4-20mA DC with HART communications.

   e. Slot fillers for unused I/O slots

3. Required Features: The I/O modules and system hardware supplied shall incorporate the following design and construction features and comply with the following requirements:

   a. Noise immunity and filtering.

   b. IEEE surge-withstand rating to IEEE 472.

   c. Optical isolation for all inputs and outputs to provide controller logic protection.

   d. Any card, any slot, plug-in packaging. Mechanical keying of I/O module to its removable terminal block (RTB) to ensure module is placed in correct slot after removal. Electronic keying between I/O module and processor ensures correct module type and revision. All modules shall be replaceable under power.

   e. Software configuration of modules (no jumpers or switches).

   f. 300 volt I/O wiring terminal arms sized to accommodate up to #14 AWG wires. Wiring design shall allow I/O module removal and replacement without disturbing I/O wiring connections.

g. Front-of-module LED Status indicators for each individual input and output point are to indicate when power is applied at I/O terminals.

h. Fused output circuits for all output modules with blown fuse indication.

i. Where required and recommended by the manufacturer, external transient suppressor shall be provided for installation across the output loads.

j. Provide required connectors with each I/O module.

4. All I/O, including future and spare, shall be wired to terminal blocks prior to interconnection with other devices.

2.4 PANELVIEW OPERATOR INTERFACE TERMINAL

A. General:

1. Operator Interface Terminals (OIT's) shall be utilized as the interface to the PLC for a specific subsystem or particular process, as shown on the CONTRACT Drawings. All stations shall be functionally similar as to display arrangements, menu selections, command terminology, and data access methods.

2. All OIT's of a given type shall be functionally interchangeable differing only in the software installed on each type. All OIT's shall be capable of accessing typical operator process control functions. Each station's functional environment shall be password protected for system security and user identification. Required number of OIT's shall be provided as shown.

B. OITs shall be conform to the following requirements:

1. Display Screen Size: 15 inches, diagonally measured.

2. Resolution: 1024 x 768 18-bit color graphics.

3. Display and keypad type: Color active-matrix TFT display and Stainless-steel membrane keypad.

4. Operating System: Windows CE 6.0

5. Memory: 512 MB.

6. Storage Memory: 512 MB of flash memory on a removable compact Flash card to hold all required process application, alarm, help, form and recipe pages.

7. Supply Voltage: 120 VAC.

8. Communications: Ethernet

9. Mounting: Unit shall be mounted on the front face of panel, as indicated on the Drawings. UL Listed., NEMA 4x (indoor and outdoor application)

10. PROFIBUS NETWORK

L. CONTRACTOR installed Profibus DP networks shall be implemented as shown on the Network Block Diagrams. Profibus DP protocol shall be used to support communications

to drives, starters, power monitors, motor protection relays, protection relays and other specialty equipment which require independent power. Profibus DP routes shall be limited to 400 meters maximum with data transmission rates of no less than 500Kbps. Network connection and support accessories shall include but not be limited to the following:

1. CONTRACTOR furnished Profibus cabling for DP networks shall be polyolefin insulated, solid copper, 22-AWG shielded twisted pair as manufactured by **Belden Cables, part number 3079A**. Cabling shall be protected by a CPE, water-resistant, UV-resistant purple jacketing. The furnished cable shall carry a UL NEC Type PLTC listing.

2. Profibus surge arrestors shall be installed only as shown on the Network Block Diagrams. Field surge arrestors shall be as manufactured by **Pepperl and Fuchs, model F-LBF-D**. Panel surge arrestors shall be din-rail mounted and shall be as manufactured by **Pepperl and Fuchs, model DP-LBF**.

3. Profibus DP network active terminators (24VDC) shall be as manufactured by **Siemens 6ES7**.

4. Other Profibus DP network components shall be as detailed on the Network Block Diagrams. Profibus networks shall be limited to 15 devices maximum with distribution as shown on the Network Block Diagrams.

5. The CONTRACTOR shall supply all taps, connectors, jumpers, terminators, adapters, transceivers, power supplies, etc. to construct a fully functional control/communication PB-DP network as required by the Contract Documents.

6. With CONTRACTOR completion of installation and testing of the Profibus network, system installation and performance shall be independently inspected and tested by a COMPANY selected testing agency (during pre-commissioning activities) to ensure network compliance with industry standards and in accordance with the performance standards applied by the network equipment manufacturers and specified herein. The CONTRACTOR shall be issued a copy of the final test report which shall highlight all areas of sub-standard performance as well as recommended corrective action. The CONTRACTOR shall be required to execute the corrective action (or other solution as may be agreed upon with the COMPANY and the ENGINEER) at the CONTRACTOR's expense (if deemed a cabling/termination installation problem) and respond in writing to the ENGINEER (for review and approval) of having completed the corrective action work prior to system Performance Testing. The report shall include the results of any re-testing required as part of the corrective action execution.

~~2.06 PORTABLE LAPTOP~~

~~A. All programming shall be accomplished from a portable laptop or from a workstation through direct serial link to the PLC or over the control system network. The laptop shall be capable of being plugged into the PLC. All PLC interface hardware and programming software shall be supplied. Programming, monitoring, searching, and editing shall be performed by the laptop. These functions shall be capable of being performed both "on-line" while the processor is scanning or "off-line".~~

~~1. One ruggedized laptop computer shall be furnished by the CONTRACTOR. Complete software shall be furnished for each laptop. A protective carrying case, AC adapter, external optical wheel mouse and spare lithium ion battery pack shall also be included for each unit. The laptop computers shall be as manufactured by~~

DELL PRECISION M4700 or ENGINEER approved equal with 2.7GHz Intel Core i7-3740QM vPro Processor, 750GB hard disk (minimum), 64GB of RAM, and three USB 2.0 ports. An integral or external DVD RW / CD RW unit shall also be supplied. The unit shall be equipped with a 15.6 inch anti-glare FHD, shock resistant hard drive and waterproof /dust resistant keypad and display

2. The unit supplied shall be capable of displaying multiple series and parallel contacts, coils, timers, counters, and calculate functions. The laptops shall also be able to monitor the status of all inputs, outputs, timers, counters, and coils. It shall have the capability to disable/force all inputs, outputs, and coils to simulate system operation. It shall also indicate "power flow" through all elements and include a search function to locate any element and its program location. The processor status information, such as error indication and amount of memory remaining, shall be shown on the display screen.

3. The laptops shall be equipped with an integrated 10/100/1000 Base T (RJ45) Ethernet connection, and a V.90/56K modem communication port. Each unit shall have an integral wireless connection option which is IEEE 802.11b/g/n compliant.

4. Each ruggedized laptop shall be portable, allowing for use in an industrial environment, without special protection. The CONTRACTOR shall provide the laptops, complete with manuals, to the OWNER to enable future system support. The laptops shall be forwarded to the OWNER during start up training. The laptop shall be purchased with 3 Year ProSupport Services and 3 Year Accidental Damage Services.

5. Laptop shall be delivered to the OWNER upon completion of the project.

2.06 UNINTERRUPTABLE POWER SUPPLY (UPS)

A. Provide and install line interactive UPS units where indicated and as specified on the Network Block Diagrams.

1. The UPS shall maintain conditioned power to all associated loads under normal conditions (line power available) and also under battery powered conditions (for the specified time period). UPS submittals shall include sizing calculations, which support the battery size selected and detail projected battery life at 50% and 100% of maximum load at the average ambient temperature of the indicated installation environment.

2. UPS units mounted within panels shall be secured to a shelf attached to the panel backplane. Floor mounted UPS units shall be subject to NEC code clearance requirements.

3. Furnished UPS units shall be as manufactured by **Powerware with Indicated communication option.** Reference the P&ID network block diagrams for specific models and options.

2.07 WORKSTATION AND SERVER HARDWARE

A. IBM compatible personal computers (PC's) complete with keyboard, optical cursor positioning device and LED monitor shall be provided by the CONTRACTOR as shown in the Network Block Diagrams. Each computer shall be furnished in a lockable tower chassis or rack mountable chassis as indicated in the contract drawings. All applicable software and hardware manuals, disks and CD's shall accompany each computer.

Computers provided shall support the latest AGP, PCI, ISA and USB bus architectures and all industry standard multi-media functions (including microphones) as an integral part of the system. All computer systems shall be as manufactured by Dell or ENGINEER approved equal. For hardware reference clarity, the term "Server" shall refer to the Master Historian; the term "Workstation" shall refer to all other computers, rack mounted or desktop, shown on the Network Block Diagrams, including the SCADA I/O, Webspace and Windows Domain servers. All computing hardware shall come with media disks.

B. Central Processing Unit (CPU): The CPU for each Workstation shall be Intel Pentium Xeon E5 processor with a minimum clock frequency of 3 GHz. The Server shall be furnished with Intel Xeon E5-2643 processors with a minimum base clock frequency of 3.3 GHz.

1. Cache Memory: Each Workstation shall have a minimum of 10M cache memory and 1600 MHz system bus (minimum). The Server shall support 1600 MHz system bus (minimum) with 10MB cache.

2. Random Access Memory (RAM): A minimum of 64GB RDIMM memory modules shall be installed within each Workstation. The Server shall be furnished with a minimum of 128GB RDIMM installed.

3. Color Monitor: Computer monitors, where indicated on the Network Block Diagrams, shall be 23 inch or 21 inch (viewable) flat screen, backlit LED type. Each color monitor supplied shall have a minimum resolution of 1920 x 1080 and shall have a minimum viewing angle of 85°. The color monitor shall be manufactured by DELL. (monitor case color shall match computer chassis; shared monitors shall be black). In addition, each Workstation shall be furnished with an Nvidia QUADRO 2000 video adapter. The server shall use an integrated NVIDIA video card with 32MB of shared video memory.

4. Disk Drives: Each Workstation chassis shall include four drive bays and shall be furnished with two 500G SATA drives. The Server shall be equipped with two 2TB 7.2K RPM SATA drives.

5. I/O Ports: Each Workstation and Server shall be provided with a minimum of one bi-directional parallel port and one RS-232 serial port and four USB 3.0 ports

6. Mass Storage: Each SCADA I/O Server (Primary and Backup) shall be supported by an external, Network connected, Dell PowerVault Removable Disk Storage System, model RX400 (or Dell recommended equivalent). The rack mounted unit shall include two drives in a four drive chassis and shall be supplied complete with manufacturer recommended tape backup software and connection cables. The unit shall include two 3Tb SAS drives. The unit shall be supplied complete with manufacturer recommended tape backup software and any required interconnecting cables.

7. Additional Mass Storage: Workstations and Servers shall be furnished with an internal DVD / CD R/RW unit, installed and configured. The unit shall support as a minimum, 16x record speed and 32x playback speed. The DVD / CD R/RW unit shall be as manufactured by Dell. Drive color shall match computer chassis.

8. Network Communications: Each Workstation (as shown on the Network Block Diagrams) shall be furnished with three integrated 10/100/1000 Base-T auto-sensing network interface cards (NIC), tested and configured. The NIC shall be capable of automatically detecting and then selecting either 10, 100 or 1000 Mbps network

speeds. It shall support a parallel tasking architecture with bus mastering capability. The NIC shall be suitable for operation at the maximum clock speed of the workstation's CPU. (Note: SCADA I/O and Webspace servers shall be configured as detailed on the Network Block Diagrams.) The Server shall be equipped with (2) dual port 10/100/1000 Base-T NIC's configured as noted on the Network Block Diagrams.

9. Modem: Each SCADA I/O server shall be equipped with an internal PCI V.92 56Kbps modem configured for dial-out only to support Win 911 callout functions. Dial-in shall be strictly prohibited. Modem shall be as manufactured by US Robotics. The CONTRACTOR shall route two phone lines from the phone system terminal backplane to the main console to support modem connectivity (in accordance with contract requirements) and coordinate service activation with the OWNER.

10. Power Supply: The Server, as well as the Windows Domain Server (primary and backup) and the Webspace Server, shall be furnished with redundant, hot-swappable power supplies and redundant cooling fans with internal temperature monitoring. All Workstations shall include internal temperature monitoring.

11. Service Contract: The CONTRACTOR shall obtain and finance a hardware service contract with a local representative of the dealer or manufacturer, effective for 3 years. The service contract shall include, but not be limited to the following:

    a. A minimum of 24 hour response time to all hardware failure calls.

    b. A minimum 48 hours "hot swap" response time. Should extensive repairs be required, the service contract shall ensure like or equal replacement hardware within 48 hours of original problem notification.

    c. Manufacturer qualified on site service technicians. Should on site service be required, the service contract shall ensure that all on site technicians are qualified by the manufacturer to perform repairs and/or upgrades on the equipment under the service contract.

    d. The service contract shall cover all workstations, printers, and peripheral equipment specified in this section.

2.08 PRINTERS

A. General:

1. Provide a high speed laser color printer.

2. Printer shall be Ethernet Compatible

3. The printer shall be HP Laser Jet Pro 400 Color MFP M475dw or equal.

2.10 SPARE PARTS

A. PLC spare parts shall include the following:

1. One (1) PLC I/O card of each type.

2. One (1) PLC CPU

~~3. One (1) PLC memory card~~

~~4. One (1) PLC communication module (if a separate module is required)~~

~~5. One (1) PLC power supply~~

PART 3 – EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies which it provides. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it provides.

B. All components of the SCADA System including all communication cabling shall be the installation responsibility of the CONTRACTOR unless specifically noted otherwise. The installation of the communication network shall be the complete installation responsibility of the CONTRACTOR including all cables, connectors, transceivers, and any required electrical grounds. Grounding shall be shown on submittal drawings. After installation of the SCADA is completed, the installation shall be inspected jointly by the CONTRACTOR and the SYSTEM INTEGRATOR. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the ENGINEER.

The certification shall state that all PLC communication and I/O modules, system grounds, communication network, and all other components of the SCADA system have been inspected and are installed in accordance with the manufacturer's guidelines.

C. The PLC and I/O racks shall be installed such that all LED indicators and switches are readily visible with the panel door open and such that repair and/or replacement of any PLC component can be accomplished without disconnecting any wiring or removing any other components.

D. All network (copper and fiber) cabling shall be certified prior to use. UTP cable shall be certified to EIA/TIA category 6A standards using a logging certification type tool or approved equal. Fiber optic fibers shall be tested using an OTDR analyzer with launch cables as required or approved equal. Reference section 3.4 - Fiber Optic Cable Testing for testing requirements.

3.2 FACTORY TEST

A. General: Prior to the delivery and installation of the SCADA System at the Site, but after the procurement, assembly, and configuration of all components, the CONTRACTOR, in conjunction with the SYSTEM INTEGRATOR, shall conduct a factory test. This test shall be witnessed by representatives of the OWNER and the ENGINEER. The factory test is intended to be a complete SCADA System check. The factory test shall demonstrate the functionality and performance of specified features of the PLC. The test shall include verification of all PLC's. A complete system checklist shall be available during the test for recording results of selected points.

B. Test Setup: The PLC's, PLC programming terminal, and communication devices shall be loaded with their applicable software packages and configuration programming. PLC input

and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures. The SYSTEM INTEGRATOR shall have a complete, up to date set of wiring drawings for review throughout the test. The SYSTEM INTEGRATOR shall have a complete PLC register list for review throughout the test.

C. All testing shall be coordinated with the CONTRACTOR. CONTRACTOR shall schedule the factory test after receiving approval of the factory test procedures submittal.

D. Test Procedure: The factory test shall be conducted in accordance with the previously submitted and approved test procedures. The test procedures shall include written descriptions of how individual tests shall be performed and shall incorporate testing the following features as a minimum. All testing shall be completed in one continuous factory test which may extend over several continuous days if necessary.

1. Power Failure: External power to enclosures shall be turned off and back on in order to test the operation of the UPS units.

E. Test Report: The SYSTEM INTEGRATOR shall record the results of all factory testing on preapproved test forms which the OWNER's and ENGINEER's representatives shall sign. A copy of the completed test forms and a report certifying the results shall be provided to the ENGINEER within 10 days of completing the test.

F. Rework and Retest: If the SCADA does not operate as required, the CONTRACTOR and/or SYSTEM INTEGRATOR shall make whatever corrections are necessary, and the failed part of the tests shall be repeated. If, in the opinion of ENGINEER's representative, the changes made by the CONTRACTOR and/or SYSTEM INTEGRATOR for such a correction are sufficient in kind or scope to effect parts of system operation already tested, then the effected parts shall be retested also. If a reliable determination of the effect of changes, then the ENGINEER's representative may require that all operations be retested. The CONTRACTOR shall bear all of its own costs for the factory test, including any required retesting.

3.3 COMMUNICATIONS BANDWIDTH TEST

A. **General:** Prior to the start-up of the PLCS at the Site the Contractor shall conduct a Communications Bandwidth test. This test shall be witnessed by representatives of the Owner and the Engineer. The test is intended to test the communications systems. The test shall demonstrate the throughput and bandwidth of specified communications features of the PLCS. The test shall include verification of all PLCs, communications cards, and remote I/O systems. Each network shall be checked. A complete system checklist shall be available during the test for recording results of selected points. The objective of this test is to prove the communication systems can perform at 90% capacity for 7 days without failure.

B. **Test Setup:** The complete PLCS system as shown on Sheets 1I-1 through 1I-6 shall be assembled and interconnected on site. The interconnection shall include communication cable segments for the LANs and the workstation network to simulate as closely as possible the eventual final installation. The PLCs, PLC programming terminal, workstations, and communication devices shall be loaded with their testing programming. The testing program is a temporary program that will send and receive messages as required to use 90% of the reported bandwidth. PLC input and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures.

C. Contractor shall schedule the test after receiving approval from the ENGINEER. The Instrument Supplier shall provide the Contractor with written notice of the start and expected duration of the factory test at least 30 days prior to the start of the test.

D. **Test Procedure:** The test shall be conducted in accordance with the previously submitted and approved test procedures. The test procedures shall include written descriptions of how individual tests shall be performed and shall incorporate testing the following features as a minimum. All testing shall be completed in one continuous test.

1. Communication: Verification that an alarm is generated upon loss of communication with any PLCS component.

2. Network Criteria: Verification of specified limits of each network in the PLCS System. (Example: RS232-9600kbaud)

3. Network Test Limits: Verify Test program would produce 90% of the specified network's limit. (Example: RS232- 8640kbaud)

4. Test Program: The test program would create a message every second with 8640K bits of data using a space for an incremented value or a time stamp. The data would be saved to data registers and printed out for evaluation.

5. Logs: Any available logs that would represent the communications' faults would be included in the reports.

6. Reports: The test shall include hourly rate calculations, number of errors per hour, and downtime records.

7. Failure Tolerance: After the 7 day test the PLCS shall be demonstrated to comply with fault tolerance requirements by simulating the failure of the communication network. Opening and replacing the cable shall result in the communication failure and the program shall restart the transmissions. The results shall be included in the reports.

8. Power Failure: After the 7 day test the PLCS shall be demonstrated to comply with fault tolerance requirements by simulating the power failure of the communication network. Turning off the transmission device shall result in the communication failure. Turning on the transmission device shall restart the transmissions. The results shall be included in the reports.

E. **Test Report:** The CONTRACTOR shall record the results of all testing on preapproved test forms which the OWNER's and ENGINEER's representatives shall sign. A copy of the completed test forms and a report certifying the results shall be provided to the ENGINEER within 10 days of completing the test.

F. **Rework and Retest:** If the PLCS does not operate as required, the Contractor shall make whatever corrections are necessary, and the failed part of the tests shall be repeated. If, in the opinion of Engineer's representative, the changes made by the SYSTEM INTEGRATOR for such a correction are sufficient in kind or scope to effect parts of system operation already tested, then the effected parts shall be retested also. If a reliable determination of the effect of changes made by the SYSTEM INTEGRATOR cannot be made, then the ENGINEER's representative may require that all operations be retested. The Contractor shall bear all of its own costs for the factory test, including any required retesting.

G. **Test Equipment:**

1. Profibus – The SYSTEM INTEGRATOR shall use Profitrace Software to evaluate all Profibus Communication Systems. The software shall be used to quantify the quality of the signals on the Profibus Network. During the test this software shall evaluate transmissions to each slave device to ensure the slave is sending and receiving messages as directed by the master. The messages shall be evaluated to verify the physical network is built correctly, as explained by the Profibus Installation Guide for Cabling and Assembly (www.profibus.org), and that the slave node can interact with the master as specified by the manufacturer's literature without errors.

2. Modbus – The SYSTEM INTEGRATOR shall use simulation software (for example: Modbus PLC Simulator) to evaluate all Modbus Communication Systems. The software shall be used to quantify the quality of the signals on the Modbus Network. During the test this software shall evaluate transmissions to each slave device to ensure the slave is sending and receiving messages as directed by the master. The messages shall be evaluated to verify the physical network is built correctly, as explained by the Modbus Serial Line Planning and Installation Guide (www.schneider-electric.com pub no: 33003925.01), and that the slave node can interact with the master as specified by the manufacturer's literature without errors.

3. Ethernet – The SYSTEM INTEGRATOR shall use simulation software (for example: Wireshark) to evaluate all Ethernet Communication Systems. The software shall be used to quantify the quality of the signals on the Ethernet Network. During the test this software shall evaluate transmissions to each device to ensure the device is sending and receiving messages. The messages shall be evaluated to verify the physical network is built correctly, as explained by the IEEE 802.3 standards, and that the devices can interact with each other as specified by the manufacturer's literature without errors.

4. RS232 – The SYSTEM INTEGRATOR shall use simulation software (for example: Serialtest, www.fte.com) to evaluate all Serial Communication Systems. The software shall be used to quantify the quality of the signals on the Serial Network. During the test this software shall evaluate transmissions to each device and ensure the device is sending and receiving messages. The messages shall be evaluated to verify the physical network is built correctly and that the devices can interact with each other as specified by the manufacturer's literature without errors.

3.4 TESTING, AND INSTALLATION

A. All testing shall be coordinated with CONTRACTOR.

B. Testing: After the SCADA installation has been certified, the system shall be tested to verify that all inputs and outputs of both the PLC systems and the area control stations HMI graphic displays are correct. All I/O points shall be checked "end to end." For example, valve operation shall be checked by stroking the valve open/closed, verifying the valve physically went open/close and the open/close limit switch feedback was properly received at the PLC input and operator area control stations HMI graphic display. Simulated testing shall be allowed only when no practical alternative exists. An I/O checklist shall be used to record test results and a copy provided to the ENGINEER upon completion.

C. System Testing: When the SCADA installation has been certified and discrete I/O testing has been completed, system testing shall be performed in accordance with the approved test procedures. System testing shall operate the various process systems of the

treatment plant to verify compliance with all functional requirements specified, including the automatic control modes and the SCADA interlocks described in the control strategies. Tests which fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.

D. During system tests, the CONTRACTOR shall have a representative on site continuously, which is capable of trouble-shooting and modifying the hardware, wiring and cable interconnections, network components, instrument configuration, etc., associated with the SCADA system.

E. The CONTRACTOR shall submit to the ENGINEER a system testing completion report when each process system and all aspects of the configuration software have been successfully tested as described herein. The report shall note any problems encountered and what action was required to correct them. It shall include a clear and unequivocal statement that the process systems have has been thoroughly tested and are complete and functional in accordance with all specification requirements.

F. Plant Start-Up Test: The CONTRACTOR shall provide start-up support to include the SYSTEM INTEGRATOR's personnel, electrical personnel, the CONTRACTOR, and the SCADA system manufacturer's representative as required during the testing period to produce a fully operational treatment plant. This support shall be provided as part of the WORK.

G. Performance Test

1. Subsequent to the system and plant start-up testing of SCADA System operation, the CONTRACTOR shall conduct a successful 90 day final acceptance test for the SCADA System. In the test, the entire SCADA System shall be continuously operated and maintained (i.e., 7 days per week, 24 hours per day) during the test period with zero downtime resulting from system failures. If a system failure occurs, the 30 day test shall be considered a failure and not acceptable. The CONTRACTOR shall repeat the 90 day test. The SCADA System shall be acceptable only after all equipment and software has satisfied the performance test requirements.

2. Downtime resulting from the following shall be considered system failures:

   a. If a component or software failure cannot be repaired/replaced within 2 hours.

   b. Downtime of any component (exclusive of I/O) whose failure results in the inability of the Operator to monitor and manipulate control loops from the associated area control stations using standard interface procedures.

   c. Downtime in excess of 2 hours resulting from any I/O component failure.

   d. Downtime resulting from concurrent failure of 2 or more I/O components in a single PLC.

   e. Downtime of any component/peripheral associated with the communication network if the failed component (1) results in a disabling of the historical functions and (2) the failed component is not repaired or replaced within 8 hours.

3. The CONTRACTOR shall submit a final performance test completion report which shall state that all CONTRACT requirements have been met and which shall include

(1) a listing of all SCADA equipment maintenance/repair activities conducted during testing and (2) a listing of all components which were unable to operate successfully. Final acceptance, in writing, of the SCADA System shall be provided by the ENGINEER if the results of all of the performance tests are acceptable.

4. After acceptance of all required performance tests, the CONTRACTOR shall be responsible for furnishing the spare parts/tools on site at an inventory level the SYSTEM INTEGRATOR determines is sufficient. All spare parts/tools stored on-site shall become the property of the OWNER upon completion of the guarantee period. The CONTRACTOR shall guarantee that the completed system shall perform all of the data acquisition, control, and reporting functions as indicated.

3.5 FIBER OPTIC CABLE TESTING

A. The SYSTEM INTEGRATOR shall perform pre-installation and post-installation Fiber Optic Cable (FOC) tests to certify the FOC system, cable segments and components. The OWNER and ENGINEER shall have the opportunity to witness all FOC testing and test results. The CONTRACTOR shall be notify the OWNER and ENGINEER a minimum of 10 days in advance of the tests.

B. The FOC testing shall adhere to the ANSI/ TIA -568-C. FOC certification shall include two parts; Tier 1 or Basic Test Regimen and Tier 2 or Extended Test Regimen

C. Test equipment: The SYSTEM INTEGRATOR shall use the following equipment, or equal, to perform pre-installation and post-installation FOC testing.

1. Optical Time Domain Reflectometer (OTDR): The OTDR shall be laser precision, Fiber Instrument Sales, Inc./FIS Hand Held Certification Mini-OTDR Model OVM-9299AHH with valid calibration documentation, or approved equal.

2. The OTDR shall be equipped with an 850 nm and 1300 nm stable light source for the multi-mode fiber testing.

3. The CONTRACTOR may opt to use an Optical Loss Test Set (OLTS) analyzer in lieu of, or in conjunction the OTDR.

D. Pre-Installation Tests: Prior to the FOC installation, the following tests shall be performed:

1. The purpose of the pre-installation testing is to perform acceptance tests on the cable prior to installation. The pre-installation testing shall verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes.

2. Prior to removal of each cable from the delivery reel, all optical fibers within the cables shall be tested by the SYSTEM INTEGRATOR using an OTDR. The tests shall consist of end-to-end attenuation (dB/km) measurements to ensure proper performance of the fiber optic cable. The tests shall be performed in at least one direction at the 850nm and 1300 nm wavelengths.

3. Pre-installation test results shall be compared with the manufacturer's test report delivered with the cable. Dissimilarities shall be documented and resolved between the CONTRACTOR and manufacturer. In all cases, all fibers must meet the optical attenuation specifications prior to cable installation.

4. For 62.5/125 µm multimode fiber, the maximum, overall attenuation is 3.5 dB/km for the 850 nm source and 1.5 dB/km for the 1300 nm source.

E. Post-Installation Tests: After FOC has been installed the following tests shall be performed:

1. The purpose of the post-installation testing is to perform acceptance tests on the premises FOC system after completion of the entire cable segment including connectors, splices, patch cords, etc. The post-installation testing shall verify that the FOC system is free of defects, breaks and damages from installation and handling.

2. Prior to placing the FOC network in service, all optical fibers within the cables shall be tested by the SYSTEM INTEGRATOR using an OTDR. The tests shall consist of end-to-end attenuation (dB/km) measurements to ensure proper performance of the FOC network The tests shall be performed with a stable light source of 850nm and 1300 nm wavelengths. Unless otherwise specified, acceptable losses are less than or equal to 0.75 dB per mated connection and less than or equal to 0.3 dB per splice.

3. Post-installation test results shall be compared with the ANSI/ TIA -568-C Standard for the installed FOC system. Deviations from the specification shall be documented and resolved by the SYSTEM INTEGRATOR. In all cases, all FOC network must meet the specifications prior to being placed in service.

END OF SECTION

SECTION 40 80 00 - CELLULAR PHONE AUTODIALER ALARM SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The work covered by this Section consists of furnishing, installing, testing and placing in operation an approved cellular autodialer alarm system for monitoring wetwell levels and normal power at pump stations under construction. Work will include all permits, labor, equipment, appliances and materials, and performing all operations required for the installation and operation of a cellular phone transceiver as necessary to minimize wastewater overflows during construction operations. This work will include all costs associated with installation and maintenance of each system during construction/rehabilitation of lift stations.

B. The cellular phone autodialer alarm system will permit alarm autodialing and remote monitoring over the cellular telephone network. If an alarm occurs, an autodialing system will automatically call a list of pre-programmed phone numbers, calling each number in turn until it gets an answer. When answered, the system reports the station identity and alarm condition by way of a digitally recorded voice message. Called stations can include standard landline phones, pagers, other cellular phones and voicemail systems. In addition to alarm reporting, the contractor or Owner can call the alarm system at any time from any standard touch tone phone to get the present status of all monitored functions.

1.2 RELATED WORK

A. Section 01 11 00: Summary of Work.

B. Section 01 52 00: Construction Facilities and Temporary Controls.

PART 2 - PRODUCTS

The Cellular Alarm Autodialer System shall be Raco – Cellularm or approved equal manufacturer that can demonstrate a minimum of 3 years of operation and a list of five municipal clients.

PART 3 - EXECUTION

A. The cellular autodialer alarm system will consist of a 3-watt analog cellular transceiver, 2.5 dB gain antenna, and autodialer packaged in a single, integrated unit. The unit will be packaged in a rugged, weather-resistant housing that will need to be locked down/secured at the site. Enclosure shall be fiberglass with silicone gaskets NEMA 4X, UL Approved. Damaged or vandalized units shall be replaced at no cost to the Owner.

B. The unit shall be AC power supplied. AC Input Range - Voltage: 90 to 260 VAC. Frequency: 47 to 440 Hz. In the event AC power is not available at each pump station site, the unit shall be DC powered, utilizing heavy duty rechargeable batteries. Back-up batteries shall be capable of providing 72 hours of system operation upon loss of normal power and are to be utilized for both transceiver and autodialer.

C. The contractor is required to purchase, furnish and install a cellular phone autodialer alarm system for each of the pump stations undergoing construction simultaneously.

D. It is the contractor's responsibility to contact the local cellular dealer or service provider to determine the availability of an AMPS analog network and make all necessary arrangements for operation. The contractor is responsible for all associated costs.

E. The system will monitor high water alarm condition and loss of normal power for each pump station undergoing construction simultaneously. In the event of an alarm condition, the system will communicate the pump station number and the type of alarm.

F. In the event of a high water condition or loss of normal power alarm, the cellular phone autodialer alarm system shall be capable of calling a minimum of four pre-programmed phone numbers, calling each number in turn until it gets answered. Three phone numbers (including numeric pager and alphanumeric pagers) for the contractor; one for WUD communications. The phone numbers shall be automatically dialed until one number is answered. WUD communications shall be called only if the three previous phone numbers for the contractor are not answered.

G. The contractor shall provide all cable, conduits, floats, contact switches, relays, hangers and other mechanical devices or housings or necessary appurtenances to provide a completely functional alarm system tested and ready for operation prior to start of construction or site work at every pump station site. The units, together with wiring, backup batteries and necessary hardware shall be installed in a first class manner consistent with all electrical and electronic system codes and practices of installation.

END OF SECTION

PART 1 – GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR, through the use of an INSTRUMENT SUPPLIER, shall provide Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents. For the purpose of this CONTRACT, PCIS is synonymous and interchangeable with Supervisory Control And Data Acquisition (SCADA) and distributed control system (DCS), where applicable

B. The SYSTEM INTEGRATOR shall be a single firm, corporation, or other entity assuming full responsibility through the CONTRACTOR to perform all engineering and to select, furnish, program, configure, integrate, supervise the installation and connections, test, calibrate, and place into operation all instrumentation, controls, communication hardware and software. The System Supplier shall specialize and have an experienced engineering and technical staff in the design, integration, and supply of systems similar to the one in these Contract Documents. The term "System Supplier" shall mean the same as "SCADA System Supplier" or "PCIS Supplier.

C. The SYSTEM INTEGRATOR shall provide training and documentation for the Instrumentation Systems, in accordance with the Contract Documents.

D. The requirements of this Section apply to all components of the Instrumentation Systems unless indicated otherwise.

E. SYSTEM INTEGRATOR Qualifications

1. The SYSTEM INTEGRATOR shall demonstrate and adhere to the following qualifications:

a. SYSTEM INTEGRATOR must provide proof of successful completion of previous projects over the prior three years, at minimum, and shall be subject to one or more audits, at the OWNER's discretion, before, during, or after the project. Successful project completion includes, but is not limited to, delivery in accordance with contract obligations, delivery within the contract schedule, and delivery of prompt positive response to field failures.

b. SYSTEM INTEGRATOR shall supply examples of and references from at least three similar projects that they have successfully completed within the past five years involving the following communications networks.

1) Modbus
2) Profibus
3) Ethernet

c. SYSTEM INTEGRATOR shall supply examples and references from at least three similar projects that they have successfully completed within the past five years involving each of the following hardware and software (software versions to be current version at the time work performed).

1) ControlLogix PLCs

2) RSLogix 5000
3) Panelview Plus
4) Rockwell Software FactoryTalk View Studio

d. SYSTEM INTEGRATOR shall have an office or location staffed with competent engineers that shall be used for the Work within 200 miles of the job site.

F. Responsibilities

1. The SYSTEM INTEGRATOR and qualified electrical and mechanical installers shall be responsible to the OWNER for the implementation of the network installation and the integration of control devices provided under this project all in accordance with the requirements of the Contract Documents.

2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the SYSTEM INTEGRATOR be responsible for the integration of new devices provided herein with devices provided under other sections with the objective of providing a completely integrated control system free of signal incompatibilities.

3. The CONTRACTOR shall request the OWNER to demonstrate that all existing equipment that is to be reused or interfaced with in this project works properly for the intended function. In the event the existing equipment does not work, the issue should be brought up in the preconstruction/ pre-submittal meeting(s). As a minimum, the SYSTEM INTEGRATOR shall perform the following work in conformance with the Contract Drawings and specifications:

a. Integrate the PCIS with existing devices and systems provided under this and other Divisions

b. Prepare hardware and software submittals.

c. Design, develop, and electronically draft loop drawings and control panel designs.

d. Prepare the test plan, the training plan, and the spare parts submittals.

e. Procure hardware.

f. Field verify existing conditions

g. Fabricate PLC panels.

h. Install PLC panels

i. Install fiber optic patch panels and install and terminate fiber optic cables.

j. Furnish, install and configure the network components to communicate and operate as outlined in the contract documents including, but not limited to, Ethernet, Profibus and Modbus networks. Certify System performance.

k. Furnish and install network equipment racks and control console to accommodate control system, equipment, security equipment, and access control equipment as outlined in the contract documents.

l. Furnish, install, power, and configure all Process Control and Instrumentation System hardware depicted on the network block diagrams (and further detailed in the specifications, installation details, and panel details), ready for installation of the project control programs and control screens.

m. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.

n. Furnish, install, power, and configure CCTV, access control or security systems.

o. Furnish, install, power, configure and calibrate all instruments depicted on the process control and instrumentation diagrams (and further detailed in the specifications and installation details).

p. Repair or replace defective hardware provided under the contract.

q. Purchase, install, and configure application software, ready for download of custom programs.

r. Provide configuration support and upgrades to address any software issues not directly attributable to the developed control programs or control screens.

s. Provide HMI remote access configuration.

t. Perform with the CONTRACTOR, PLC-based control system – software Factory Acceptance Test.

u. Perform pre-testing and troubleshooting of all loops (and document the results of this testing) prior to the arrival of the ENGINEER. Perform corresponding loop drawing updates prior to witnessed loop testing with the CONTRACTOR.

v. Oversee, document, and certify loop testing.

w. Provide validation sheets for loop-by-loop commissioning.

x. Provide on-site hardware and software support services during system commissioning. Respond time shall be a maximum of 24 hours after notification unless otherwise scheduled with the ENGINEER.

y. Prepare Owner's Manuals.

z. Provide training.

aa. Prepare record drawings.

G. Certification of Intent

1. Each Bidder shall include with the Bid the following Certification from the selected System Supplier:

a. The Certification shall be typed on the System Supplier firm letterhead.

b. It shall be signed by an authorized representative of the System Supplier's firm.

c. It shall include the following statements:

1) (Corporate name of System Supplier) "hereby certifies intent to execute and assume full responsibility to the CONTRACTOR to perform all tasks defined under Division 40 in full compliance with the requirements of the Contract Documents.

2) It is certified that the requirements will be performed by qualified personnel.

3) It is certified that the quotation to the CONTRACTOR includes full and complete compliance with the requirements of the Contract Documents without exception.

H. Integration of instrumentation and control devices being provided under other sections:

a. Develop all requisite loop drawings and record loop drawings associated with equipment provided under other Divisions of these Specifications.

b. Resolve signal, power, or functional incompatibilities.

c. Integrate Vendor Control Panel (VCP) communications into the plant control network.

2. Integration with network components being provided under separate Contract.

1.2 WORK BY OTHERS

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all WORK specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this Section; provided, that where such documents have been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence.

B. The PCIS WORK shall conform to or exceed the applicable regulations, standards, specifications, and codes which are referenced in Section 01 42 19 - Reference Standards, and current as of the date of the final inspection for this Contract, including, but not limited to, those which are established by the following sources:

1. The International Society of Automation (ISA)

2. National Electrical Code (NEC)

3. National Fire Protection Association (NFPA)

4. Institute of Electrical and Electronic Engineers (IEEE)

5. Occupational Safety and Health Administration (OSHA)

6. American National Standards Institute (ANSI)

7. National Electrical Manufacturers Association (NEA)

8. Insulated Cable Engineers Association (ICEA)

9. Local Power and Telephone Companies

10. Local Authorities having jurisdiction over the work

11. Federal Communication Commission (FCC)

12. Underwriter Laboratory (UL)

C. Where the requirements set forth in these Specifications or on the Drawings are greater or more rigid than the mandatory requirements referenced above, the applicable Specifications or Drawings shall govern.

D. In the case of conflict between any mandatory requirements and Specifications or Drawings, the mandatory requirement shall be followed in each case, but only after submitting such proposed changes to the ENGINEER for approval.

E. Nothing contained in these Specifications or shown on the Drawings will be so construed to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including the National Electrical Code, are hereby incorporated and made a part of these Specifications. All such requirements will be satisfied by the CONTRACTOR at no additional expense to the OWNER.

F. The Drawings and Specifications are complementary to each other; what is called for by one shall be as binding as if called for by both. If a conflict between Drawings and Specifications is discovered, this shall be referred to the ENGINEER as soon as possible for resolution. Should a conflict exist between the Drawings, Specifications, and/or mandatory requirements (i.e., codes, ordinances, etc.), it will be assumed that the more expensive method has been estimated, unless such alternate has been agreed to prior to submission of bids.

1.4 CONTRACTOR SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 01 33 00 – Submittal Procedures, and the following:

1. The SYSTEM INTEGRATOR shall coordinate the instrumentation work so that the complete instrumentation and control system will be provided and will be supported by accurate shop drawings and record drawings.

2. The submittals and their schedules shall be shall be in accordance with the requirements listed below: Any incomplete submittal will be rejected and returned without comments.

3. Interface between instruments, motor control centers, engines, starters, control valves, flowmeters and other equipment related to the PCIS shall be included in the shop drawing submittal. Interface between existing equipment, instruments and control panels shall also be included,

4. Exchange of Technical Information: During the period of preparation of these submittals, the SYSTEM INTEGRATOR shall authorize a direct, liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the ENGINEER, but will not alter the scope of work or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

5. Symbols and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbols as derived from Instrument Society of America Standard ISA S5.1 - Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.

B. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a presubmittal conference in conformance to Specification 01 33 00 – Submittals Procedures. The purpose of the presubmittal conference is to review the manner in which the SYSTEM INTEGRATOR intends to carry out its responsibilities for Shop Drawing submittals on the WORK to be provided under this Section.

2. Before preparing the submittals the CONTRACTOR shall meet with the OWNER and visit the project site(s) to obtain information and inventory regarding the existing conditions. Interface to existing equipment, control and monitoring circuits shall also be reviewed. During the inventory the CONTRACTOR shall determine the location of the new equipment that is part of this contract. Any major conflicts with the contract documents shall be brought to the ENGINEER's attention at the pre-submittal conference The CONTRACTOR shall also review the available as built drawings.

3. The CONTRACTOR shall allot two, 8 hour days for the pre-submittal conference.

4. In addition to the requirements of Specification 01 33 00 – Submittal Procedures, the CONTRACTOR shall submit materials for the conference including:

   a. A list of instruments and control network equipment required for the process control and instrumentation system and the manufacturer's name and model number for each proposed item.

b. A sample of each type of submittal required herein.

c. A bar-chart type schedule for system-related activities from the presubmittal conference through final acceptance. The schedule shall include dates and duration for submittal preparation, submittal reviews, allowance for resubmittals, design, workshops, fabrication, programming, factory testing, deliveries, installation, field testing, production of record documentation, and training. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule. The details of the SYSTEM INTEGRATOR'S schedule shall be reflected in the CONTRACTOR'S schedule.

d. The SYSTEM INTEGRATOR shall submit presubmittal materials as a bound package, complete and at one time a minimum of 90 calendar days prior to the commencement of the submittal process for work under divisions 26, 28, 40, 43 and 46. It is the responsibility of the CONTRACTOR and SYSTEM INTEGRATOR to coordinate work under this division with work under other divisions of the specifications.

5. The CONTRACTOR shall take minutes of the pre-submittal conference, including events, questions, and resolutions. Prior to adjournment, attendees must concur with the accuracy of the minutes and sign accordingly.

C. Shop Drawings

1. General:

a. All shop drawings shall include the letter head or title block of the SYSTEM INTEGRATOR. The title block shall include, as a minimum, the SYSTEM INTEGRATOR's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing the quantity of submittal sets shall be as indicated in Specification 01 33 00 – Submittals Procedures.

b. Organization of the shop drawing submittals shall be compatible with eventual submittals for later inclusion in the Owner's Manual. Submittals not so organized and incomplete submittals for any given loop will not be accepted.

c. Shop drawing information shall be bound in standard size, 3 ring, loose-leaf, vinyl plastic, hard cover D-ring binders suitable for bookshelf storage. Binder ring size shall not exceed 3 inches.

d. Interfaces between instruments, control valves, and other equipment shall be included in the shop drawing submittal.

D. System Hardware Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the submittal for the System Architecture, and Communication Diagrams submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified below.

2. Submittal Contents:

   a. The submittal shall be for the hardware specified under Division 40.

   b. The submittal shall include a complete index which lists each device by type, and manufacturer in accordance with the contract documents. A separate manufacturer technical data sheet or brochure shall be included for each hardware component. If, within a single system a single component is employed more than once, one manufacturer technical data sheet or brochure may cover multiple identical uses of that component in that system. Special options and features which are furnished shall be identified.

   c. The submittal shall include load calculations and size of the various UPS systems to demonstrate that the UPS is able to accommodate present and future load requirements, as well as overload capacity requirements.

   d. System Architecture and Communication System Diagrams: The CONTRACTOR shall develop and submit project-wide system architecture and communication diagrams, which present the system architecture, the network(s), and radio communication as applicable. The submittal shall include a set of drawings that presents the following as applicable:

      1) System architecture and network (copper and fiber optic) physical topology schematic, including servers, workstations, hardware nodes, network hardware such as routers, cabling converters, etc., and connections.

      2) System architecture and network (copper and fiber optic) physical topology schematic, including servers, workstations, hardware nodes, network hardware such as routers, cabling converters, etc., and connections.

      3) Radio communication, cabling and connections including within a panel and the antenna.

3. Spare Parts and Tools List: A list of spare parts and tools shall be submitted, covering items which are specified and furnished under this Contract. The list shall include the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts. The list shall also include recommended spare parts and tools, quantities and prices from which the OWNER will select the "Additional Recommended Spare Parts and Tools".

E. Hardware Submittal: The SYSTEM INTEGRATOR shall submit a hardware submittal as a bound package, complete and at one time, including:

   a. A comprehensive Instrument List. The submitted instrument list shall be in the Record Instrument List format and completed to the extent possible. The ENGINEER shall furnish an initial Instrument List populated with the general requirements and process information for each device.

   b. A technical product brochure or product bulletin for each type of instrument submitted. The technical product brochure/bulletins shall contain adequate information to verify conformance to all Contract Document requirements. Catalog cuts must identify all components of the model number, sizes, ranges, ratings, options, etc. Cover sheet of catalog cut shall be identified with job

name and instrument tag names. The catalog cut and specification data sheet must completely agree with each other or the submittal will be rejected without further review.

c. Copies of the Project Specification Data Sheets populated with the instrument requirements and process information for each type of field instrument on the project are furnished under these specifications.

1) Where final selection of instruments requires further coordination with the instrument manufacturer, the associated equipment requirements, and/or the process conditions, the forms include the use of the following abbreviations;

a) TBD - To Be Determined

b) VTA - Vendor to Advise

c) VTC – Vendor to Confirm

2) In several cases instrument vendors are listed without a specific instrument model or series number. These vendors are listed for reference. The vendor may, or may not, have an approved equal instrument available for submittal. The submittal reviewer is under no obligation to accept the named vendor if the SYSTEM INTEGRATOR has not demonstrated that the instrument meets or exceeds the requirements of the specification data sheet.

d. The SYSTEM INTEGRATOR shall submit fully populated Specification Data Sheets. The submitted Specification Forms shall include the information furnished by the ENGINEER as well as the detailed information derived from the device as submitted in the Hardware Submittal, associated equipment requirements, and the process conditions.

1) The form shall identify the instrument tag, instrument type, description, process data, service, line number or vessel number, location, manufacturer, complete model numbers, voltages, materials of construction, ratings, connection type, ranges, calibration data, set points, settings and other parameters as listed on the data sheet.

e. The Specification Data Sheets shall be submitted in both a printed hard copy and an electronic format. Electronic files shall be submitted as an editable, native file such as Microsoft Excel. Note: PDF files do not meet the requirement for editable files.

f. Instrument installation, mounting, and anchoring details shall be submitted in an electronically generated hard copy format. Each instrument or group of similar instruments shall have a dedicated 8½-inch X 11-inch detail, which only pertains to the specific instrument installation. Each detail shall be in accordance with the instrument manufacturer's recommendations. Where needed to ensure the proposed installation is fully warrantable, obtain certification by the instrument manufacturer. These certifications shall be embedded in the CAD files and shall also appear as a stamp on the hard copies. As a minimum, each detail shall have the following contents:

1) Show all 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, humidity, and corrosive qualities of the environment that the instrument is to be installed in.

3) Hazardous rating of the environment that the instrument is to be installed in.

4) Process line pipe or tank size, service and material.

5) Process tap elevation and location

6) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.

7) Routing of tubing and identification of supports.

8) Mounting brackets, stands, and anchoring devices.

9) Conduit entry size, number, location, and delineation between power and signal.

10) NEMA ratings of enclosures and all components.

11) Clearances required for instrument servicing.

12) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

2. Loop Drawing Submittal:

a. The SYSTEM INTEGRATOR shall furnish a Loop Drawing Submittal which completely defines and documents the contents of each monitoring, alarming, and interlock control loop associated with equipment provided under Division 40 sections and equipment provided under sections in other Divisions. The Loop Drawing Submittal shall be a singular complete bound package electronically drafted in AUTOCAD, submitted and reviewed a minimum of 30 days before wiring terminations of PLC input and output field wiring may begin. A review status of MAKE CORRECTIONS NOTED or APPROVED is also required before wiring terminations begin. Field wiring for any given I/O point including, but not limited to, field wiring at PLC enclosures, Remote I/O enclosures, vendor control panels, and hard-wiring at the field equipment may not begin prior to submittal and review of the corresponding loop drawing. The Loop Drawing Submittal shall include the following:

b. A complete index in the front of each bound volume. The loop drawings shall be indexed by systems or process areas. All loops shall be tagged in a manner consistent with the Contract Documents. Loop drawings shall be submitted for every analog and discrete monitoring loop.

c. Drawings showing definitive diagrams for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component of each loop or system using legend and symbols from ANSI/ISA S5.4 - Instrument Loop Drawings. Panel drawings showing PLC I/O card wiring and field terminations are not acceptable as loop drawings. Each system or loop diagram shall be drawn on a separate drawing sheet. Loop drawings shall be developed for loops in equipment vendor supplied packages and equipment provided under Division 40. In addition to the expanded ISA S5.4 requirements the loop diagrams shall also 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) Panel and breaker numbers for all power feeds to the loops and instrumentation.

4) Designation, and if appropriate, terminal assignments associated with every manhole, pullbox, junction box, conduit, and panel through which the loop circuits pass.

5) Vendor panel, instrument panel, PLC panel, termination identification wire numbers, wire sizes and colors, power circuits, and ground identifications.

3. Control Panel Documentation Submittal:

a. The SYSTEM INTEGRATOR shall provide Control Panel shop drawings.

b. The Control Panel Submittal shall be a singular complete bound package electronically drafted in AUTOCAD.

4. Software Submittals:

a. The SYSTEM INTEGRATOR shall provide Software submittals.

b. An initial software submittal shall be provided for review of the overall software requirements and project approach. Subsequent submittals shall be provided prior to each Coordination Workshop described in this section.

c. Electronic files in pdf format, generated from the native files, shall be provided for each review.

5. Test Procedure Submittals:

a. The SYSTEM INTEGRATOR shall conform to the testing requirements of the contract documents. The SYSTEM INTEGRATOR shall be responsible for the coordination of the testing and test schedule with OWNER personnel.

b. The SYSTEM INTEGRATOR shall submit detailed testing procedures to demonstrate an understanding of and conformance to OWNER requirements.

c. Submittal Schedule: The SYSTEM INTEGRATOR shall submit for approval a proposed procedure to be followed during startup and commissioning of the PCIS and its components **complete within 270 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but not later than **60 calendar days** prior to the Factory Acceptance Test date. The CONTRACTOR shall submit the proposed.

d. Preliminary Submittal: Outlines of the specific procedures and examples of proposed forms and checklists.

e. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed procedures, forms, and checklists. This submittal shall include a statement of objectives with the test procedures.

6. Factory Acceptance Tests (FAT):

a. Prior to shipment, the PCIS including all panels, integrated SCADA system, PLCs, peripherals, communications equipment, etc. provided under this Division, shall be assembled, connected, and all software loaded for a full functional factory acceptance test (FAT) of the integrated system. Existing equipment is not required to be included in this test.

b. In preparation for the FAT, the CONTRACTOR shall check, troubleshoot, debug and test the PCIS prior to arrival of the ENGINEER in order for the PCIS to be ready for the FAT, minimize testing time, and minimize re-testing during the visit. Similar testing shall be performed even if the ENGINEER chooses not to witness the FAT.

c. The CONTRACTOR shall allow the ENGINEER and OWNER to inspect the PCIS and witness the functional testing of the system at the site of assembly and integration of the system.

d. A minimum of 21 Days notification shall be given to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER's approval. A successful completion of the test is a prerequisite to the shipment of the system.

7. Training Submittals: The CONTRACTOR shall submit a training plan which includes:

a. Schedule of training courses including dates, durations, and locations of each class.

b. Format for the training defining lecture format and field training segments.

c. Materials to be distributed at the training such as manuals, record documentation, programming documentation, calibration documentation, etc.

d. Resumes of the instructors who will actually implement the plan.

8. Communication Field Survey and Test Procedure Submittal

a. Submittal Schedule: The CONTRACTOR shall submit for approval a comprehensive communication field survey and test procedure **complete within 120 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.

b. Submittal Contents: The submittal shall include a communication survey and proposed tests with example(s) of proposed forms and checklist. The radio survey and test procedure shall result in generating as a minimum, the required parameters and data (e.g. antenna height, fade margin, receive signal strength, path quality, etc.) in order to implement a reliable communication system as specified in Division 27.

F. Operation and Maintenance Manual:

1. General: Information in the Operation and Maintenance Manual shall be based upon the approved shop drawing submittals as modified for conditions encountered in the field during the WORK, as well as detailed documentation of the implementation of the WORK.

2. The Operation and Maintenance Manual shall have the following organization:

a. Section A - Loop Descriptions

b. Section B – Loop Drawings

c. Section C - I/O List

d. Section D – Panel Drawings and Wiring Diagrams

e. Section E – Instrument List

f. Section F – Instrument Data Sheets

g. Section G – Instrument Calibration Forms

h. Section H - Instrument Installation Details

i. Section I - Manufacturer Cut Sheets and Shop Drawings

j. Section J - Test Results

k. Section K – Fully commented copy of PLC program (to be inserted after successful completion of the Performance Test)

l. Section L – HMI Graphic Control Screens (to be inserted after successful completion of the Performance Test)

m. Section M Test Results

3. A comprehensive I/O List including all parameters listed below shall be included in Section C, I/O List. The final format for the list will be provided to the System Integrator during construction.

a. Tag and Description

b. Signal type and level

c. Signal range, engineering units, and setpoints

d. Alarm High, High-High, Low, Low-Low and Alarm Class information

e. "Signal From" details including panel, terminal block, and terminal

f. Power Source

g. PLC termination details including panel, terminal block, and terminal

h. PLC address and register information

4. A comprehensive Instrument List including all parameters listed below shall be included in Section E, Instrument List. The final format for the list will be provided to the System Integrator during construction.

   a. Tag, Equipment Location, and Control Loop Description

   b. Instrument Type, Service, Size and Connection

   c. Actual Calibration ranges and setpoints

   d. Manufacturer and Model

   e. Spec Section and Drawing number references

   f. Submittal number, Instrument data sheets numbers, and installation detail number references

5. Signed forms from System Checkout and Start-up, Commissioning, and Performance Testing shall be included in Section J and M, Test Results.

6. Initially, draft Operation and Maintenance Manuals shall be submitted for review after return of favorably reviewed shop drawings and data required herein. Following the ENGINEER's review, the Manuals shall be revised and amended as required and the final Manuals shall be submitted 15 days prior to start-up of systems.

G. Record Drawings

1. The SYSTEM INTEGRATOR shall keep current a set of complete loop diagrams, wiring diagrams, installation details, and network diagrams. These drawings shall include all instruments and instrument elements. One set of drawings electronically formatted in AUTOCAD and 2 hard copies shall be submitted after completion of all Precommissioning tasks but prior to Performance Testing. All such drawings shall be submitted for review prior to acceptance of the completed work by the OWNER.

1.5 MILESTONE SCHEDULE OF VALUES

A. General: The CONTRACTOR shall develop a schedule of values based upon the payment milestones noted below.

B. Payment Milestones: This schedule lists the percentage of the lump sum price of Instrumentation which will be payable to the CONTRACTOR upon task completions. Payment shall be in accordance with the General Conditions.

1.	Hardware Equipment Submittal approved	5 percent
2.	Project-wide Loop Drawing Submittal approved	10 percent
3.	Control Panel Engineering Submittals approved	5 percent
4.	Final Technical Manual submitted	5 percent
5.	Completion of testing and commissioning accepted	35 percent
6.	Thirty-day performance test successfully completed	30 percent
7.	Notice of acceptance issued	10 percent

1.6 SPECIAL CORRECTION OF DEFECTS REQUIREMENTS AND WARRANTEE

A. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee specified in Division 1. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.

B. Extended Period for Correction of Defects: The CONTRACTOR shall correct defects in the PCIS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 5 Days after notification.

C. The performance of the servers and workstations hardware shall be guaranteed (repair of parts and labor at the owner's site including travel expenses) for a period of three (3) years following the date of completion and formal acceptance of the work (next business day on-site service).

D. Software Upgrades: During the warrantee period, the CONTRACTOR shall furnish and install at no additional cost to the OWNER any application software upgrades published applicable to OWNER's applications and compatible with OWNER's hardware and operating system.

PART 2 -- PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

A. Code and Regulatory Compliance: WORK shall conform to or exceed the applicable requirements of the National Electrical Code. Conflicts between the requirements of the Contract Documents and any codes or referenced standards or specifications shall be resolved according to Section 01 42 19 - Reference Standards.

B. Standard and Current Technology: All PCIS hardware, software, materials, and equipment furnished under this contract shall be new, free from defects, and shall be standard products and technology produced by manufacturers regularly engaged in the manufacturer of these products. Meters, instruments, and other components shall be the

most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment. The CONTRACTOR shall submit a Substitute Item Request Form in case of discontinued or upgraded product or other cases where changing technology requires changes in equipment or software.

C. Alternative Equipment and Methods: Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process of the Contract Documents. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

D. Adverse Environmental Impact: No component of an instrumentation system shall contain liquid mercury.

E. Hardware Commonality and Modularity: Instruments which utilize a common measurement principle shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer. All equipment shall be of modular design to facilitate interchangeability of parts to assure ease of servicing and expandability.

F. Loop Accuracy: The accuracy of each instrumentation system or loop shall be determined as a probable maximum error; this shall be the square-root of the sum of the squares of certified "accuracies" of the designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual instrument shall have a minimum accuracy of plus and minus 0.5 percent of full scale and a minimum repeatability of plus and minus 0.25 percent of full scale unless otherwise indicated. Instruments which do not conform to or improve upon these criteria are not acceptable.

G. Instrument and Loop Power: Power requirements and input/output connections for all components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2-wire" transmitters is preferred, and use of "4-wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as required by the Manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.

H. Environmental Suitability: All indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation devices 20% within the minimums and maximums of their rated environmental operating ranges. The SYSTEM INTEGRATOR shall provide all power wiring for these devices. Enclosures suitable for the environment shall be furnished.

I. Signal Levels: Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals shall be 4 to 20 mA DC except as indicated.

J. Lightning Surge Protection: Signal, communications and power lines for outdoor instruments and equipment shall be provided where indicated on the Contract drawings and as noted in the Contract specifications. Surge arrestors shall be provided at both the instrument/equipment termination and the associated panel termination.

K. Instrument Isolation Valves: Instrument isolation valves shall be 1/2" stainless steel, full port, ball valves with Teflon seats and packing.

2.2 OPERATING CONDITIONS

A. The Components shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:

1.	Environment	-	Corrosive Waste Water Treatment Facility
2.	Temperature Range	-	32 through 104 degrees F
3.	Thermal Shock	-	1 degree F per minute, max
4.	Relative Humidity	-	20 through 90 percent, non-condensing

2.3 SPARE PARTS AND SPECIAL TOOLS

A. The CONTRACTOR shall provide the specified spare parts and tools. In addition, The ENGINEER and the OWNER will select from the priced list of "Additional Recommended Spare Parts" in the Hardware Equipment Submittal.

B. The CONTRACTOR shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided from which the ENGINEER or the OWNER will select the needed tools. After approval the CONTRACTOR shall furnish tools on that list. The cost of these tools will be included in the allowance.

C. The CONTRACTOR shall furnish one (1) portable instrument loop calibrator with current simulator with charger and carrying case.

D. The CONTRACTOR shall furnish the following spare parts

1. Ten (10) spare CAT 6A patch cables.
2. Ten (10) spare Fiber Optic patch cables.
3. Ten (10) spare fuses for each range.
4. Quantity of spare relays of each type – 10% of total supply
5. One (1) panel 24V power supply
6. One (1) Profibus power supply
7. One (1) Profibus scanner PLC module
8. One (1) digital input and digital output PLC I/O module for every five (5) supplied, minimum of one (1) each spare.

9. One (1) analog input and analog output PLC I/O module for every three (3) supplied, minimum of one (1) each spare.

10. One (1) pressure switch of each type supplied

11. One (1) pressure gauge of each type supplied

12. One (1) pressure transmitter of each type supplied

PART 3 – EXECUTION

3.1 PRODUCT HANDLING

A. Shipping Precautions: After completion of shop assembly, factory test, and approval, all equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the Manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Tagging: Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment. Identification shall be prominently displayed on the outside of the package. Tags shall be attached to instruments using stainless steel wire.

D. Storage: It is the CONTRACTOR's responsibility to assure proper handling and on-site storage of Instrumentation and control equipment in accordance with the System Supplier's recommendations. All equipment and materials delivered to the jobsite shall be stored in a location which will not interfere with the operations of other contractors or the OWNER. Equipment shall not be stored outdoors. Storage and handling will be performed in manners which will afford maximum protection to the equipment and materials.

E. Equipment shall be stored in dry shelters, including in-line equipment, and shall be adequately protected against mechanical damage. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.2 MANUFACTURER'S SERVICES

A. The SYSTEM INTEGRATOR shall furnish the following Manufacturer's services:

1. Oversee installation.

2. Verify installation of installed instrument.

3. Oversee System Checkout and Start-up, certify installation and reconfirm Manufacturer's accuracy statement.

4. Oversee commissioning, prepare commissioning documentation, and certify pre-commissioning.

5. Train the OWNER's personnel

B. Manufacturer's services: In addition to requirements detailed in other sections, for each listing below, manufacturer onsite field services shall be reserved (at no additional cost to the OWNER) for the time periods indicated or, where no time period is specified, to complete the services described.

1. Ultrasonic field mounted transit time liquid flow measuring systems (Pipe Mounted)

2. DO, pH, ORP, NH3, NO3, TSS Analyzers.

3. Atmosphere Monitoring System (Gas Monitoring).

C. The CONTRACTOR shall procure the services of authorized Cisco field technicians (at no additional cost to the OWNER) for the configuration and startup of the network Ethernet switches and routers (with all applicable integral functions and security protocols).

D. The CONTRACTOR shall procure the services of authorized Rockwell Automation field technicians (at no additional cost to the OWNER) for the configuration and startup of the software and firewall for the Factorytalk remote access clients.

E. The CONTRACTOR shall procure the services of authorized Rockwell Automation field techniques (at no additional cost to the OWNER) for the configuration of process control communications.

3.3 INSTALLATION

A. General:

1. All systems and instrumentation, including instrumentation furnished under other Divisions, shall be installed, connected calibrated, tested, started, and placed into operation in accordance with CONTRACT documents under Division 40 and the manufacturers' instructions. The installation shall be coordinated with the ENGINEER and the OWNER. This shall include final integration in concert with equipment specified and provided by others.

2. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all PCIS equipment.

3. The CONTRACTOR shall furnish the services of an on-site engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The engineer shall be present during the total period required to affect a complete operating system. A team of engineering personnel shall be at the site for 80 hours to check equipment, perform the tests indicated in this Section, and furnish startup services.

4. Equipment Locations: The monitoring and control system configurations indicated in the contract documents are diagrammatic. The locations of equipment are approximate unless dimensioned. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.

5. The CONTRACTOR shall 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.

6. The Contract Documents identify conduits and instruments required to make a complete PCIS. The CONTRACTOR shall be responsible for providing any reasonable additional or different type connections as required by parts of the PCIS' specific installation requirements, or as practical.

B. Conduit, Cables, and Field Wiring

1. Conduits, process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments and to control panels, DCS, SCADA, PLC input and output wiring, and other field wiring and cables shall be provided under Division 26 and without delay to the WORK of Division 40.

2. DCS, SCADA, PLC, equipment cables, data highway communication networks shall be provided under Division 40, but the installation in the field shall be under Division 26.

3. Terminations and wire identification inside PCIS equipment and panels furnished under this or any other Division shall be provided under Division 40.

4. The CONTRACTOR shall supervise and coordinate installation and termination and identification of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.

C. Installation and Connections:

1. Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site. Appropriate mounting stands and bracket materials and workmanship shall be provided and shall comply with requirements of the Contract Documents.

2. Existing Instruments that are to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.

3. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation. The CONTRACTOR shall be responsible for providing

any additional or different type connections as required by the Instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.

4. Field Connection Panels and Interface Terminal Blocks: In cases where field I/O wiring has to be extended to a control panel or from enclosures or devices that are removed, the CONTRACTOR shall provide separate enclosures or junction boxes with interface terminal blocks that will serve as a field connection panel (FCP). The FCP and the terminal block shall be shown on the project-wide wiring diagrams.

5. Conduits and/or raceways in building interior locations shall be surface mounted on walls or ceilings wherever possible and run perpendicular and parallel to building lines. Conduits shall not be routed on floors in areas subject to foot traffic. In exterior locations conduit shall be routed below grade.

6. Wires and cables shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.

7. Signal and low voltage wiring shall be run in a separate conduit from power and 120-volt control wiring.

8. Field wiring shall terminate at terminal blocks in the control panel. Field wiring shall not be wired directly to equipment in the control panel except communication and specialty cables that must be wired directly to their respective equipment.

9. Power and signal wires shall be terminated with crimped type lugs.

10. Wires shall be marked clearly with an identification wire number labels that are of a permanent nature. Computer system equipment cables shall be identified and marked for their location at each end of the cable. Computers and peripheral equipment connections/ports shall also be identified as to what cable is connected to its port location.

11. Connectors shall be, as a minimum, water tight.

12. Sensing Lines and Tubing:

    a. Instrument process sensing lines shall be installed in conduit under Division 26 and in a manner similar to the conduits. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.

    b. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.

13. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.

14. Differential pressure elements shall have 3 valve manifolds.

15. The CONTRACTOR shall verify the correctness of each installation, including polarity of electric power and signal connections. The CONTRACTOR shall certify in writing all discrepancies have been corrected for each loop or system checked out. In addition, the CONTRACTOR shall make sure process connections are free of leaks.

16. All SCADA equipment cables, fiber optic cables, network cables, field bus cables and data highway communication networks shall be provided under Division 40.

D. Removal of Abandoned Equipment: Unless otherwise specified, all existing equipment in each facility that is no longer required after the new system has been put in service shall be removed and delivered by the CONTRACTOR to the OWNER.

3.4 CALIBRATION

A. General:

1. Devices provided under Division 40 shall be initially calibrated by the manufacturer at the manufacturer's facility prior to shipment. Following installation, the devices shall be field calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements. The CONTRACTOR shall also field calibrate existing instruments if it is part of a modified loop.

2. Each instrument shall be field tested, inspected, and adjusted to the indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirement, or, in the absence of a contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

B. Calibration Points: During bench and field calibration each instrument shall be calibrated at least at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs and outputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Bench Calibration: Instruments that have been bench-calibrated by the manufacturer shall be verified in the field after installation to determine whether any of the calibrations are in need of adjustment.

D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name
2. Loop number and site or process name and number
3. Tag number
4. Manufacturer
5. Model number
6. Serial number
7. Calibration range
8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span
9. Switch setting, contact action, and dead-band for discrete elements
10. Space for comments
11. Space for sign-off by System Supplier and when applicable by the manufacturer and date
12. Test equipment used and associated serial numbers

G. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the System Supplier sign the calibration sheet when calibration is complete. The ENGINEER will sign the calibration sheet when the calibration and testing has been accepted.

3.5 LOOP TESTING

A. **General:** Individual instrument loop diagrams per ISA Standard S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the ENGINEER for review prior to the loop tests. The SYSTEM INTEGRATOR shall notify the ENGINEER and OWNER of scheduled tests a minimum of three weeks prior to the estimated completion date of installation and wiring of the SCADA system. After the ENGINEER and OWNER review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed.

B. **Construction Sequence:** Due to the nature of this project, it is anticipated that loop testing will be performed in phases to closely coordinate with the WORK performed under other specification sections. Installation and wiring of the SCADA equipment within an area of the facility shall be completed prior to initiating loop testing in that area.

C. **Interlocks:** Hardware and software interlocks between the instrumentation and the packaged equipment controls shall be checked to the maximum extent possible.

D. **Instrument and Instrument Component Validation:** Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance with its manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER at no additional cost to the OWNER.

E. **Loop Validation Sheets:** The SYSTEM INTEGRATOR shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the SYSTEM INTEGRATOR:

1. Project name.
2. Loop number.
3. Tag number, description, manufacturer, and model number for each element.
4. Verify Electrical Power Wiring.
5. Verify Control System input and output wiring.
6. Space for comments.
7. Space for loop sign-off by SYSTEM INTEGRATOR and date.

F. **Loop Certifications:** When installation tests have been successfully completed for all individual instruments and all separate analog control networks, a certified copy of all test forms signed by the SYSTEM INTEGRATOR as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.

3.6 PRE-COMMISSIONING

A. General:

1. Pre-commissioning, which is defined in Section 01 75 00 – Starting and Adjusting, is basically the demonstration of proper operation of every part in the PCIS with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible. All systems shall be exercised through field operational tests, as a complete PCIS in accordance with the approved test procedures and in the presence of the ENGINEER and/or the OWNER.

2. Pre-commissioning shall commence after completion and acceptance of continuity tests, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with contract requirements.

3. Pre-commissioning Procedures and Documentation: Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be

recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system pre-commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied. The result of the testing shall also include a punch list developed by the ENGINEER.

4. The burden of proof of conformance of the system to specified functions and performance is on the CONTRACTOR. Tests that fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.

5. The CONTRACTOR shall supply necessary test equipment and technical personnel if called upon to prove accuracy and/or performance, at no separate additional cost to the OWNER, wherever the OWNER or ENGINEER has reasonable doubt or evidence of malfunction or poor performance appears.

6. The CONTRACTOR shall coordinate the scheduling of tests among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. Field operational and functional testing must be successfully completed prior to the start of the 30-day final acceptance test.

B. Operational Validation:

1. Where feasible, system pre-commissioning activities shall include the use of the actual process to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, PLCs, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational.

2. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of process controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

3. Pre-commissioning shall also include the testing of remote sites to verify compliance with all functional requirements and communication specified. The testing shall include manual and automatic control modes, fail-safe and backup control modes, and PLC interlocks and control strategies provided by the System Supplier.

C. Loop and Equipment Tuning: Controllers incorporating proportional, integral and/or derivative control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed set point settings shall be compared to measured final control element position/speed values at 0, 25, 50,

75, and 100 percent of span and the results checked against indicated accuracy tolerances.

D. Pre-commissioning Validation Sheets: Pre-commissioning shall be documented on test forms as follows:

1. The validation form, which shall include:

a. Project name

b. Loop number

c. Loop and function description

d. Tag number, description, manufacturer, and data sheet number for each component.

e. Pre-Commissioning Certification - A statement certifying that the contract requirements have been met. It shall also include a listing of instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

f. Space for sign-off and date by the CONTRACTOR, the System Supplier, and the ENGINEER.

3.7 COMMISSIONING

A. **General:** Commissioning shall commence after acceptance of all wire tests, calibration tests and loop tests, network configuration and testing, and all inspections have demonstrated that the instrumentation and control system complies with all Contract requirements. The SYSTEM INTEGRATOR will perform a complete system test to verify that all equipment is operating properly as a fully integrated system, and that the intended monitoring functions are fully implemented and operational.

1. The SYSTEM INTEGRATOR shall coordinate a schedule for Commissioning, with the CONTRACTOR.

2. The SYSTEM INTEGRATOR shall provide the following documentation for use during the Commissioning effort. This documentation is in addition to that included in Division 40.

a. Complete loop diagrams.

b. Provide loop-by-loop validation sheets as detailed below:

1) One (1) set of Commissioning documentation for the OWNER's personnel

2) One (1) set for field use

c. The drawings corrected and modified during Commissioning shall form the basis for the "As-Built" record drawing required.

B. **Construction Sequence:** Due to the nature of this project, it is anticipated that Commissioning will be performed in phases to closely coordinate with the WORK performed under other specification sections. All wire tests, calibration tests and loop tests, network configuration and testing, and all inspections within an area of the facility shall be completed prior to initiating Commissioning and test activities in that area.

C. **Commissioning Procedures and Documentation:** All commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. All test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step.

D. **Commissioning Validation Sheets:** Commissioning shall be documented on one of two types of test forms as follows:

1. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:

   a. Project name.

   b. Loop number.

   c. Loop description.

   d. Tag number, description, manufacturer, model number and data sheet number for each component.

   e. Verify PLC logic is complete.

   f. Verify PanelView points and displays are complete.

   g. Verify HMI points and displays are complete.

   h. Space for sign-off and date by both the SYSTEM INTEGRATOR.

2. For functions which cannot be demonstrated on a loop-by-loop basis, the SYSTEM INTEGRATOR's test form will be a listing of the specific tests to be conducted. With each test description the following information shall be included:

   a. Project name.

   b. Specification page and paragraph of function demonstrated.

   c. Description of function.

   d. Verify PLC logic is complete.

   e. Verify PanelView points and displays are complete.

   f. Verify HMI points and displays are complete.

   g. Space for sign-off and date by both the SYSTEM.

3.8 FINAL ACCEPTANCE TEST (COMMISSIONING)

A. After the pre-commissioning, functional tests and startup have been completed, the CONTRACTOR shall submit a report/letter states that CONTRACT requirements have been met and the PCIS is ready for the Final Acceptance Test.

B. The entire PCIS shall go through a final 30-day acceptance test. For the purpose of this CONTRACT, the terms "Final Acceptance Test" and "Final Performance Test" are synonymous and are used interchangeably. The 30-day test must be successfully completed prior to the date of and as a condition to substantial completion of the entire project WORK. During the testing period, all system functions shall be exercised, and any system interruption and accompanying component, subsystem, software, or program failure shall be logged for cause of failure, as well as time of occurrence and duration of each failure.

C. In addition to the requirements of Section 01 75 00 – Starting and Adjusting, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements. The CONTRACTOR shall also provide a competently programmer on call during all normal working days and hours from the start of the acceptance test until final acceptance of the system. The on-call programmers shall be ready to respond within two hours of the notification of the problem.

D. Testing: The entire PCIS shall be tested and shall include, but not limited to, the field instrumentation, control and PLC panels and PLC programs, application SCADA software, graphics and trends, reports, and the control and monitoring functions. Each system function, e.g., status report-backs, alarms, logs, and displays shall be exercised several times at a minimum, and in a manner which approximates "normal" system operation. At least two displays and reports shall be generated during the test.

E. Failure During Testing: Failure of the system during the testing shall be considered as indicating that part of the PCIS does meet the requirements of the specifications and corrective action shall be required before restarting the acceptance test. Failures shall be classified as either major or minor as follows, and it is at the discretion of the ENGINEER how to classify the failure:

1. Minor Failure: A minor failure would be a small and non-critical component failure which can be corrected by the OWNER's operators. This occurrence shall be logged, but shall not be reason enough for stopping the test and shall not be grounds for non-acceptance or –restart, provided that the function(s) can be provided by backup equipment and repairs can be made and equipment returned to service within one (1) working day. However, should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance and termination of the test.

2. Major Failure: A major failure shall be considered to have occurred when a major component of the PCIS, subsystem, communication, or program fault causes a halt in 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. A major failure shall cause termination of the acceptance test. When the causes of a major failure have been corrected, a new acceptance test shall be started.

F. Technician Report: Each time a technician is required to respond to a malfunction in the PCIS he/she must complete a report which shall include details concerning the nature of

the complaint or malfunction and the resulting repair action required and taken. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report shall be required (logged as specified above). Each report shall be submitted within 24 hours to the ENGINEER or its representative, and the OWNER.

3.9 TRAINING AND INSTRUCTIONS

A. General:

1. The CONTRACTOR shall train the OWNER's personnel on the PCIS operation, maintenance, calibration, and repair of equipment provided under this Contract. The training shall be by qualified instructors. The training courses shall be given on-site to a minimum of four people of the OWNER's personnel. All instruction, tools and training material shall be provided by the CONTRACTOR.

2. These courses shall be designed to provide the operations, maintenance and supervisory personnel with training in routine and preventive maintenance of all the PCIS including instrumentation, communication, PLCs software, and HMI. The training course shall include instruction on the use of all maintenance equipment and special tools provided under the contract.

B. Instructions: The training shall be performed by qualified instructors. The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. Training Manuals and Material: The CONTRACTOR shall use the approved Training syllabus and Training Manuals to develop training material. The training material shall be designed to provide the operations, maintenance and supervisory personnel with training in routine operation procedures, and preventive maintenance and troubleshooting of the PCIS, PLCs and the computer monitoring and control systems.

D. Schedule: Training shall be performed on-site during the calibration, loop and functional testing of the PCIS prior to the 30-day Final Acceptance Test. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated. Due to availability and scheduling of the OWNER's staff, the CONTRACTOR shall coordinate with the OWNER the schedule of the classes. The OWNER reserves the right to videotape the training sessions for later use. Due to possible limited availability of the OWNER's staff, the CONTRACTOR shall provide the number of identical courses/sessions of each of the following training courses as indicated, each up to four people of the OWNER's staff.

E. Training Subjects, Duration, and Agenda: The training shall include operation and maintenance procedures, troubleshooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment. During the course, hands-on experience with the system equipment shall be provided. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PCIS and the PLCs. Operator classes shall stress operational theory and use of the PCIS and the PLCs.

1. Field Instruments

a. Duration – an average of two hours per each type of instrument

b. Subjects - Installation, setup, configuration, maintenance, calibration, and troubleshooting:

1) Pressure transmitter

2) Level transmitter

3) Flow measuring device and transmitter

4) Analyzer – liquid and gas

5) Weather monitoring

6) Temperature transmitters

7) Power monitoring equipment

8) Vibration transmitter

9) Uninterruptible power supply (UPS)

2. PLC: The training of the following subject shall be performed by the CONTRACTOR and the PLC manufacturer as noted: Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PLC. Operator classes shall stress operational theory and use of the PLCs.

a. Duration – 40 instruction hours or a minimum of 8-hours per class of PLC training.

b. Subjects:

1) PLC System Hardware and Programming Software - General Familiarity – by the PLC Manufacture.

2) PLC programming I/O, ladder logic, registers, etc. (process/site specific) – by the CONTRACTOR

3) Project specific operation and communication – by the CONTRACTOR

4) Project specific PLC program troubleshooting – by the CONTRACTOR

5) PLC Hardware- Troubleshooting and Repair of PLCs _by the PLC manufacturer or by the CONTRACTOR if approved by the ENGINEER

3. Central computer system and HMI Development

a. Duration

1) 8 hours for maintenance programmer

2) 8 hours for development training system

b. Subjects

1) HMI configuration.

2) Report and trend generation

3) Operator training

4) Programmer training

5) HMI graphics with emphasis on making changes and additions to reports and displays method to be used for scheduling and changing the scheduling of reports.

6) Data base programming, adding or deleting analog and digital points adding future data base points. linking data base points to screen displays

7) The CONTRACTOR shall provide two identical courses/sessions of development system training. Each development training system training course shall be 16 hours for graphic displays and report generation applications.

8) Integrating future PLCs into the SCADA system

9) Historical backup and maintenance.

10) Server redundancy, failure and switchover

11) Diagnostics, troubleshooting, and related procedures

4. Communication System and Network

a. Duration – 8 hours

b. Subjects –

1) Communication types and communication equipment – radio, cellular, etc.

2) PLC communication hardware

3) Network equipment and maintenance

4) Communication protocols

5) Wireless communication

6) Communication failure diagnosis/troubleshooting and repair

3.10 CRITERIA FOR SUBSTANTIAL COMPLETION

A. For the purpose of this Section and all Division 40, the following conditions shall be fulfilled before the WORK is considered substantially complete:

1. Submittals have been completed and approved.

2. The PCIS has been calibrated; loop tested, pre-commissioned, commissioned, and the startup completed.

3. The OWNER's training has been performed.

4. Spare parts and expendable supplies and test equipment have been delivered to the OWNER.

5. The Final Acceptance Test has been successfully completed.

6. Major punch-list items have been corrected.

7. As built drawings in both hard copy and electronic format have been submitted. The as built drawings shall also include annotation of the PLC ladder logic program by providing a descriptive label for all relays and function blocks and functional description of each rung.

8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.

9. Debris associated with installation of instrumentation has been removed.

10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

3.11 CORRECTION OF DEFECTS DURING CONSTRUCTION

A. The CONTRACTOR is responsible, at their expense, for the replacement and/or repair of any defective SCADA workmanship, components, hardware, equipment, application, firmware, or software, which the OWNER or ENGINEER deems to be defective. The CONTRACTOR shall respond within 24 hours of initially being contacted. Any delays to loop testing, commissioning, and programming resulting from longer response times are solely the responsibility of the CONTRACTOR.

3.12 EXTENDED PERIOD FOR CORRECTION OF DEFECTS

A. The CONTRACTOR is responsible, at their expense, for the replacement and/or repair of any defective SCADA workmanship, components, hardware, equipment, application, firmware, or software, which the OWNER deems to be defective for a minimum of twelve months after system acceptance by the OWNER. Any of the above items, which are repaired or replaced, shall be warranted for a period of not less than six months from date of the replacement and/or repair or the remainder of the original warranty term, whichever is greater.

- END OF SECTION -

SECTION 40 90 20.1 - CONTROL PANELS

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish, install and place into service operating process instrumentation, control systems and panel including accessories, related to the control panels as shown on plans and specified herein.

1.02 SINGLE INSTRUMENT SUPPLIER

A. The Contractor shall assign to the Single Instrument and Control (panel) supplier full responsibility for the functional operation of all new instrumentation systems. The Contractor shall have said supplier perform all engineering necessary to select, to furnish, to supervise installation, connection, to calibrate, to place into operation all sensors, instruments, alarm equipment, control panels, accessories and all other equipment as specified herein.

B. The foregoing shall enable the Contractor and the Owner to be assured that the full responsibility for the requirements of this section will reside in an organization which is qualified and experienced in the water treatment field and its process technology on a functional system basis.

C. The panel supplier shall be a UL listed manufacturer. Acceptable named manufactures shall be limited to the Approved Materials and Specifications listed on the Palm Beach County Water Utilities Department Minimum Design and Construction Standards for Potable Water, Reclaim Water and Wastewater Systems.

D. Contractor shall review all specifications and drawings. Contractor shall be sure all control panels are included in the bid.

E. Contractor shall provide modifications to the existing RTU.s as needed, where is applies (reusing existing RTU). Contractor shall provide new separately enclosed RTU.s where called for, per the Contract Document requirements.

F. All Control Panels shall be provided by UL approved manufacturers. Labels shall provide for all control panels.

1.03 INSTALLATION WORK

A. Nothing in this part of the specifications shall be construed as requiring the Contractor to utilize personnel supplied by his assigned instrument manufacturer's organization or any division there of, to accomplish the physical installation of any elements, instruments, accessories or assemblies specified herein. However, the Contractor shall employ installers who are skilled and experienced in the installation and connection of all elements, instruments, accessories and assemblies; portions of their work shall be supervised or checked as specified herein.

1.04 PREPARATION OF SUBMITTAL OF DRAWINGS AND DATA

A. It is incumbent upon the Contractor to coordinate the work specified in these Sections so that a complete instrumentation and control will be provided and will be supported by accurate shop and record drawings. As part of the responsibility as assigned by the Contractor, the Single supplier shall prepare and submit through the Contractor, complete and organized shop drawings, as specified herein. Interface between instruments, motor starters, flow meters, and existing instruments shall be included in his shop drawing submittal.

B. In order to provide a fully coordinated system, shop drawings by other equipment vendors associated with the control panel systems shall be reviewed and approved by the Contractor before submittal to the Engineer for approval.

'C During the period of preparation of this submittal, the Contractor shall authorize direct informal liaison between his single Supplier and the Engineer for exchange of technical information. As a result of this liaison certain minor refinements and revisions in the systems as specified many be authorized informally by the Engineer, but these shall not alter the scope of the work or cause increase or decrease in the contract price. 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 formal exception to, or variation from these specifications.

D. Operation and Maintenance Manual

1. Submit one preliminary O&M for review and comment by the Engineer. Provide five final O&M'.s, bound in a three ring binder. O&M shall include the requirements of materials and

minimally include the following: approved submittal data, start-up corrected as built shop drawings. O&M shall be neatly and logically arranged with a contents page followed by tabbed sections.

1.05 ADDITIONAL TECHNICAL SERVICES

A. At no additional cost to the Owner, the Contractor shall provide the services of qualified technical representatives of the Single supplier:

1. To supervise installation and connection of all instruments, elements and components of every system, including connection of instrument signals to primary measurement elements and to final control elements such as pumps;

2. To make all necessary adjustments, calibrations and tests;

3. To instruct plant operating and maintenance personnel on instrumentation. This time shall be in addition to whatever time is required for other facets of work at the site and shall be during the Owner's normal working days and hours.

1.06 GUARANTEE

A. The Contractor shall guarantee all equipment and installation, as specified herein, for a period of 2 years following the date of completion of the work. To fulfill this obligation, the Contractor shall utilize technical service personnel designated by the Single supplier to which the Contractor originally assigned project responsibility for instrumentation.

1.07 ADDITIONAL PROVISIONS

A. The applicable provisions of the following sections under Electrical Work shall apply the work and equipment specified herein, the same as if stated in full herein:

1. Codes and Standards

2. Equipment Materials and Workmanship

3. Testing

4. Grounding

5. Equipment Anchoring

6. Conductor and Equipment Identification

7. Terminal Cabinets and Control Compartments

8. Process Control Devices

1.08 NEWEST MODEL COMPONENTS

1. All meters, instruments and other components shall be the most recent field proven models marketed by their manufacturers at the time of the submittal of shop drawings unless otherwise specified to match existing equipment. All technical data publications included with the submittal shall be the most recent issue.

1.09 COORDINATION

A. Provide all coordination with the Owner, Engineer Suppliers and the Subcontractors.

1.10 TEST PROCEDURE DEVELOPMENT AND DOCUMENTATION

A. Panel subcontractor shall prepare and submit to the Engineer for review a detailed description of the test procedures that he proposed to perform to demonstrate conformance of the complete system of instrumentation and controls to this Specification.

B. It is recommended that the panel subcontractor develop the test procedures in two steps by first submitting general descriptions and outlines of the tests and then, upon receipt of approval, submit the required detailed procedures and forms.

C. Operational Acceptance Tests

D. Functional Acceptance Tests

1.11 SYNOPSIS OF WORK

A. Provide lift station control panels, as indicated by the drawings.

B. Provide field instruments, as indicated by the drawings.

C. Provide integrated RTU, as indicated by the drawings.

D. Provide terminal boxes, as indicated by the drawings.

E. Provide assistance and documentation for the lift station start up, as indicated on the drawings.

E. Provide start up and check out, for each station.

PART 2 – PRODUCTS

2.01 INSTRUMENTATION CRITERIA

A. Designation of Components

1. In these specifications and on the drawings, all systems, meters, instruments and other elements are represented schematically, and are designated by numbers, as derived from criteria in Instrument Society of America Standard ANSI/ISA S5.1-1973. The nomenclature and numbers designated herein and on the drawings shall be employed exclusively throughout shop drawing, data sheets and similar materials. Any other symbols, nomenclature unique to the manufacturer's standard methods shall not replace these prescribed above, used herein and on the Drawings.

B. Signal Characteristics

1. Signals shall be electrical, as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted. Electrical signals outside control panels shall be 4-20 MADC, except as noted.

C. Matching Style, Appearance and Type

1. All instruments to be panel mounted at the control panels shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class and shall be one (1) manufacturer.

D. Accuracy and Repeatability

1. The overall accuracy of each instrumentation system or loop shall be as prescribed in the specifications for that system or loop. Each system's accuracy shall be determined as a probable maximum error; this shall be the square root of the sum of the squares of the certified "accuracies" of certain designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual electronic instrument shall have a

minimum accuracy of +0.7 percent of full scale and a minimum repeatability of +0.4 percent of full scale unless otherwise specified. Instruments which do not conform or improve upon these criteria are not acceptable.

E. Signal Isolators, Converters and Power Supplies

1. Signal isolators shall be furnished and installed in each measurement and control loop, wherever required, to assure adjacent component impedance match or where feedback paths may be generated. Signal converters shall be included where required to resolve any signal level incompatibilities. Signal power supplies shall be included, as required by the manufacturer's instrument load characteristics, to insure sufficient power to each loop component.

F. Alternative Equipment or Methods

1. Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the Engineer. Any changes inherent to a proposal alternative shall be at no additional cost to the Owner. The required approval shall be obtained in writing by the subcontractor through the Contractor prior to submittal of shop drawings and data. Any proposal for approval of alternative equipment or method specified, shall include evidence of improved performance, operational advantage and maintenance enhancement over the equipment or method specified, or shall include evidences that a specified component is not available. Otherwise, alternative equipment (other than direct, equivalent substitutions) and alternative methods shall not be proposed.

G. Special Equipment

1. The Supplier shall provide all necessary equipment to properly interface his system with equipment provided by others. Such equipment shall include but not be limited to special sensing relays for seal failures and the like.

2.02 DETAILED SYSTEMS DRAWINGS AND DATA

A. Content

The Contractor shall submit detailed shop drawings and data prepared and organized by the Single supplier designated at the time of bidding. The quantity of submitted sets shall be no less than 6 sets. These drawings and data shall be submitted as a complete bound package at one time within 30 calendar days after date of notice to proceed. Provide field investigations before submittal preparation.

1. Drawings showing definite diagrams for every instrumentation loop system shall be provided. These diagrams shall show and identify each component of each loop or system using legend and symbols from ISA standard S5.4, each having the format of ISA Standard S5.1 as used on the project drawings.

2. Provide additional information per Owner/Engineer.

3. Data sheets for each component, together with a technical product brochure or bulletin shall be provided. The data sheets shall show:

   a. Component function description used herein and on the drawings;

   b. Manufacturer's model number or other product designation;

   c. Project tag number used herein and on the drawings'

   d. Project system loop of which the component is a part;

   e. Project location or assembly at which the component is to be installed;

   f. Input and output characteristics;

   g. Scale range, units and multiplier;

   h. Requirements for electrical supply;

   i. Requirements for air supply;

j. Materials of component parts to be in contact with, or otherwise exposed to process media;

k. Special requirements or features.

4. A complete index shall appear in the front of each bound submittal volume. A separate technical brochure or bulleting shall be included with each instrument data sheet. The data sheet shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure may cover all identical uses of that instrument in that system. Each brochure shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags.

5. Drawings shall show both schematic and wiring diagrams for control circuits. Complete details on the circuit interrelationship of all devices within and outside each control panel shall be submitted. Control devices and pertinent mechanical relationships including mechanical parameters shall be included on these diagrams. These parameters as a minimum shall include instrument ranges, sizes, setpoints and the like. The diagrams shall consist of component layout drawings to scale, showing numbered terminals on components together with the unique number of the wire to be connected to each terminal. Piping and wiring diagrams shall show terminal assignments from all primary measurement devices, such as flow meters, and to all final control devices, such as pumps. The Contractor shall furnish all necessary equipment supplier's shop drawings to facilitate inclusion of this information by the system supplier.

6. Assembly and construction drawings for each control panel and for other special enclosed control assemblies for field installation shall be provided. These drawings shall include dimensions, identification of all components, surface preparation and finish data, name plates and the like. These drawings also shall define exactly the style and overall appearance of the assembly; a final treatment sample shall be provided when requested.

7. Installation anchoring and mounting details for all components and assemblies to be field-mounted, including conduit connection or entry details shall be provided.

8. Complete detailed bill of materials including a master bill of materials listing all field mounted devices, control panels and other equipment that will be shipped to the job site and a bill of materials for each control panel listing all devices within the panel.

B. Organization and Binding

1. The organization of the original shop drawing submittal shall be compatible to the eventual inclusion with the technical manuals submittal and shall include final alternations reflecting "as built" conditions. Accordingly, the initial multiple copy shop drawing shall be separately bound in 3-ring binders.

2.03 TECHNICAL MANUALS

A. One preliminary O&M manual shall be submitted to the Engineer for review and comment. Assuming a favorable review, the supplier shall incorporate comments and forward the five final copies to the Engineer. If the preliminary O&M is not acceptable, the supplier shall resubmit.

B. Five (5) final sets of technical manuals shall be supplied for the Owner as a condition for final acceptance of the project. Each set shall consist of one (1) or more volumes, each of which shall be bound in a standard size, 3-ring, loose leaf, vinyl plastic hard cover binder suitable for bookshelf storage. Binder ring size shall not exceed 3 inches.

C. In addition to updated shop drawing information to reflect actual existing conditions, each set of technical manuals shall include installation, connection, operating, trouble-shooting, maintenance and overhaul instructions in complete detail. This shall provide the Owner with comprehensive information on all systems and components to enable operation, service, maintenance and repair. Exploded or other detailed views of all instruments, assemblies, and accessory components shall be included together with the complete parts lists and ordering instructions.

D. Shop drawing files shall be provided in the latest version of Autocad with each O&M manual. Provide electronic files.

2.04 SPARE PARTS

A. The Contractor shall include, as part of the bid package, a list of recommended spare parts covering items required under these specifications.

B. Minimum spare parts shall be provided boxed and identified including the following:

1. 1 ~~2~~ control relays of each type used.

2. 1 ~~2~~ timing relays of each type used.

3. 1 ~~2~~ fuses of each size and type used.

4. 1 ~~2~~ pilot lights of each size and type use.

5. 1 ~~2~~ signal field surge arrester of each type used.

6. 1 ~~2~~ signal panel surge arrester of each type used.

7. 1 ~~2~~ incoming power lightning arrester of each type used.

8. 1 ~~2~~ surge capacitor of each type used.

Also provide other spares as noted by the particular sections and paragraphs of other- specifications.

2.05 CONTROL PANELS

A. General

1. Panel supplier shall construct the control panel to properly control internal and external equipment. No attempt is made to specify or indicate on plans, all required equipment but rather to set forth the minimum requirements.

B. Engineering

1. Panel supplier shall provide system engineering and produce detailed fully engineered, coordinated and completed drawings.

C. Construction

1. Control panel construction shall be per these specification and plans.

D. Signal and Control Circuit Wiring

1. Wire Type and Sizes: Conductors shall be flexible stranded copper wire; these shall be UL listed TFFN, THWN, THHN and shall be rated 600v. Wire for control signal circuits shall be #16 AWG unless otherwise noted. All instrumentation cables shall be shielded #18 AWG with a copper drain wire unless otherwise noted. All special instrumentation cable such as between sensor and transmitter shall be supplied by the supplier. Contractor shall increase wire size per load or impedance requirements.

E. Wiring Instrumentation

1. All wires shall be run in plastic wireways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, (3) wiring run from components on a swing-out panel to components on a part of the fixed structure, (4) wiring run to panel mounted components on the door and the like. Wiring run on a swing out panel to other components on a fixed panel shall be made up in nylon wire ties bundles and secured so that bundles are not strained at the terminals.

2. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon ties and secured to the inside face of the panel using adhesive mounts and adhesive strips.

3. Wiring to rear terminals on panel mounted instruments shall be run in plastic wares secured to horizontal brackets run above or below the instruments in the same plane as the rear of the instruments.

4. Shields of instrument cable shall only be grounded on one side of each circuit. The side to be grounded shall be nearest the source of excitation.

5. Care shall be exercised to properly insulate the ungrounded side of the loop to prevent ground loops from occurring.

6. Conformance to the above wiring installation requirements shall be reflected by details shown on the shop drawings for the Engineer's review.

F Wire Marking

1. Each signal, alarm, control, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on all shop drawings. These numbers shall be marked on all conductors using white plastic heatshrink sleeves with typewritten characters. Instrument signal conductors shall be tagged with unique multiple digit numbers. Wires from the circuit breaker panelboard shall be tagged indicating the branch circuit breaker number.

G. Terminal Blocks

1. Compression type terminal blocks shall be molded plastic with barriers and box lug terminals, and shall be rated 15 amps at 600v and mounted securely to DIN rails. White marking strips fastened to the molded sections shall be provided and wire numbers and circuit identifications shall be marked thereon with machine printed marker on top. Terminal blocks shall be IEC style by Entrelec M4/6 or an approved equal.

H. Wire Color

1. Wire color shall be, Line Power – Black; Neutral or common – White; AC Control – Red; DC Control – Blue; Equipment or Chassis Ground – Green; specified externally powered circuits – Orange.

I. Identification

1. All components shall be identified using Lamicoid labels or an approved equal.

2.06 CONTROL PANEL EQUIPMENT

A. General Purpose Relays

1. General purpose relays in the control panel shall be the plug in type with contacts rated 10 amps at 120 vac as a minimum. The quantity and type of contacts shall be as

required to accomplish the desired control task. Each relay shall be enclosed in a clear plastic heat and shock resistant dust cover. Relays shall be Potter and Brumfield or an approved equal. Differing mounting sockets shall be used to prohibit improper relay installations. Provide tube type base, 8 PIN or 11 PIN. Blade type relays shall not be used.

B. Time Delay Relays

1. Time delay relay shall be Diversified with digital settings or an approved equal. Timers shall be time delay on, interval on or time delay off relays, as required and shall be Diversified or an approved equal. Instantaneous contacts or auxiliary slave relays shall be provided as required. Provide tube type base, 8 PIN or 11 PIN. Blade type relays shall not be used.

C. Signal Isolators

1. Additional slave or interposing relays and signal isolators and signal converters shall be installed as required.

D. Circuit Breakers

1 Circuit breakers shall be single pole, 120vac, 15 amp rating or as required to protect wires and equipment; mounted on the inside of the enclosure or equipment remote from the enclosure.

E. Name Plates

1. Name plates shall be supplied for identification of control panels and all field mounted elements, including flowmeters and their transmitters. These name plates shall identify the instrument or meter, descriptively as to the function of the system. Nameplates shall be fabricated from black faced, white centered, laminated engraving plastic. A nameplate shall be provided for each signal transducer, signal converter, signal isolator, each electronic trip, and the like, mounted inside the control panels. These shall uniquely identify each control component. Adhesives shall be acceptable for attaching nameplates. Painted surfaces must be prepared to allow permanent bonding of adhesives. Nameplates shall be provided for instruments, function titles for each group of instruments and other components mounted on the front of the control panels as shown.

Proposed colors, styles, height and text shall be submitted for approval.

F. Power Supplies

1. Power supplies shall be provided as required for loop power or other requirements for special equipment. Loop power supplies shall be Square D or an approved equal.

G. Circuit Breakers

1. Square D

2. Amperage ratings shall be indicated on drawings.

H. Fuses

1. Fuses and fuse holders 5x 20mm, IEC style, with blown fuse indicating light.

I. Ground Fault Interrupting Receptacle

1. Leviton Duplex Receptacle or equal.

2. AC receptacle box shall be Steel City 58351-1/2 or equal.

3. Covers shall be Steel City 58-C-5, or equal.

J. Surge and Lightning Arrestors

1. All control panels shall be provided with surge and lightning arrestors as specified.

2. Lightning Surge Suppressor

(1). Lightning surge suppressors shall be Surge Suppression, Inc., LSEA Series or equal.

3. Signal

a. Panel surge arrestors (PSA) shall be Edco PC 642C Series, 2 channel or equal.

b. Field surge arrestors (PSA) shall be Edco SS64 Series, pipe style or equal.

4. Ethernet Surge Protection

a. Atlantic Scientific, 240040P, plug in surge arrestor, via FB Suppressors, Inc., (305) 247-3477.

2.07 FIELD INSTRUMENTATION AND CONTROL EQUIPMENT SPECIFICATIONS

A. General

1. The materials specified below shall establish the type and quality of materials used.

2. Refer to Civil, Mechanical, and Electrical drawings for additional requirements.

2.08 PHOTO VOLTAIC (PV) CHARGING SYSTEM

A. Provide photo-voltaic charging system as indicated by the drawings. As a minimum, include:

1. Photo-voltaic panel system

2. Mounting systems

3. Batteries and automatic charging system

4. All labor and materials for a complete and functional system.

5. Submit material and mounting details for the complete system.

2.09 OWNER'S STANDARD MATERIALS

A. See the drawings for Owner's standard materials.

B. If conflicts arise between the standard drawings and other drawings, the other drawings shall take precedence. Other drawings shall include the oneline, plan views, details and the like.

C. The standard drawings are included so the Owner may have preferences or standardization. The standard drawings shall establish the minimum level of quality. Increase ratings as may be required.

D. Parts indicated on the drawings shall not be substituted.

E. Soft starters shall be oversized as indicated by the drawings. The next standard size rated unit shall be provided. For example, if the drawings indicate 20 hp, a 25 hp rated soft starter system shall be provided. The NEC recognized motor size shall be used as the standard basis of size. For example, if the motor is rated 19.5 hp, the higher standard size would be 20 hp. Then the next standard size rating is 25 hp. A 25 hp would be required.

2.10 NAMEPLATES, NAME TAGS AND SERVICE LEGENDS

A. All components provided under this section, both field and panel mounted, shall be provided with permanently mounted name tags bearing the entire IA tag number of the components. Panel mounted tags shall be plastic; field mounted tags shall be stamped stainless steel.

B. The panel drawings refer to nameplates and service legends: nameplates are defined as inscribed laminated plastic plates mounted under or near a panel face mounted instrument. Service legends are defined as inscribed laminated plastic integrally mounted on a panel face mounted instrument.

C. Service legends and nameplates shall be engraved, rigid, laminated plastic. Service legends and nameplates shall be fastened to the panel by screws or with a specially applied adhesive. Fastening shall not depend only on the adhesive.

PART 3 – EXECUTION

3.01 INSTALLATION, CALIBRATION, TESTING, START UP AND INSTRUCTION

A. General

1. Under the supervision of a Single supplier, all systems specified in this section shall be installed, connected, calibrated and tested and in coordination with the Owner and Engineer shall be started to place the process in operation. This shall include final calibration in concert with equipment specified elsewhere in these specifications as well as equipment provided by the Owner.

B. Installation and Connection

1. The Contractor shall install and connect all field mounted components and assemblies. The installation personnel shall be provided with a final reviewed copy of the shop drawings and data.

2. The instrument process lines, impulse piping lines and air signal tubing shall, in general, be installed in a similar manner to the installation of conduit specified under Section 16000.

3. Bends shall be formed with the proper tools and to uniform radii and shall be made without deforming or thinning the walls of the tubing.

   a. Unless otherwise indicated, all fittings, adapters, impulse piping, valves, etc. shall be 316 stainless. Valves shall be Whitey Series 40 or an approved equal.

C. Calibration

1. All new instruments shall be calibrated.

   a. All instruments and systems shall be calibrated after installation, in accordance with the component manufacturer's written instructions. This shall provide that those components having adjustable features are set carefully for the specific conditions and applications of this installation and that the components and/or systems are within the specified limits of accuracy. Defective elements which cannot achieve proper calibration or accuracy, either individually or within the system shall be replaced. This calibration work shall be accomplished by the SUPPLIER.

   b. Proof of Conformance – The burden of proof of conformance to the specified accuracy and performance is on the Contractor using his designated supplier. The Contractor shall supply necessary test equipment and technical personnel if called upon to prove accuracy and performance at no additional cost to the Owner, wherever reasonable

doubt or evidence of malfunction or poor performance may appear within the guarantee period.

D. Testing

1. All systems shall be exercised through operational tests in the presence of the Engineer in order to demonstrate achievement of the specified performance. Operational tests depend upon completion of work specified elsewhere in these specifications. The scheduling of the test shall be coordinated by the Contractor among all parties involved so that the tests may proceed without delays or disruption by incomplete work.

E. Start Up

1. When all systems are assessed by the Contractor to have been successfully carried through complete operational tests with a minimum of simulation, and the Engineer concurs in his assessment, start up by the plant operating personnel can follow.

END OF SECTION

SECTION 40 90 30 - REMOTE TERMINAL UNIT

PART 1 – GENERAL

1.01 WORK INCLUDED

A. The RTU supplier shall furnish all labor and materials to provide the remote terminal unit (RTU) including all hardware and configuration for a complete and functional system.

B. Like items of equipment provided hereunder shall be the end products of one manufacturer in order to achieve standardization for appearance, operation and maintenance.

C. RTU Supplier shall be the Control panel mafacturer in order to provide a coordinated, complete and functional system.

D. RTU Application, see the drawings.

1. Some stations Integrate the RTU into the control panel.
2. Some stations reuse the existing RTU.
3. Some stations require a new separately enclosed RTU.

E. Provide and install the following as a minimum

1. Integrate the RTU into the control panel, where indicated.
2. Rhon Antenna system
3. Allen Bradley PLC System, see the drawings
4. Radio shall match the Owners. See the drawings.
5. Coax Cable
6. Antenna
7. Onsite testing
8. Pulsar Blackbox Level Transmitter and sensor.

F. Reuse and reconnect the existing RTU as indicated by the drawings.

G. Programming of the RTU equipment shall be carried out by PBCWUD personnel, provide up to 4 hours of assistance and support as required.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 40 90 20.1 – Control Panels

B. Section 26 00 00.1 – Electrical General Provisions

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the general conditions.

1. It is incumbent upon the Contractor to coordinate the work specified in these Sections so that a complete system will be provided.

2. As part of the responsibility as assigned by the Contractor, the RTU supplier shall prepare and submit through the Contractor, complete and organized shop drawings.

1.04 QUALITY ASSURANCE

A. All equipment furnished under this specification shall be new and unused, shall be the product of a manufacturer having a successful record of manufacturing and servicing the equipment specified herein for a minimum of five (5) years.

B. Assembly and system shall be U.L. 508 listed.

1.05 WARRANTY

A. The Contractor shall warrant all equipment and programming for a period of one (1) year from the date of Owner acceptance of the system.

PART 2 – PRODUCTS

2.01 GENERAL

A. All hardware shall be provided integrate the RTU to the Owner's existing system.

B. Provide battery charging system and batteries.

PART 3 – EXECUTION

3.01 DOCUMENTATION

A. Provide six sets of completely revised O&M documents.

B. The RTU supplier shall describe all input and output elements.

C. Provide details wiring and assembly drawings for review and approval.

D. Provide details wiring and assembly drawings for the O&M manuals.

3.02 TESTING

A. All equipment shall be field tested. All elements of the system shall be checked in the presence of the Engineer and to his satisfaction. The RTU supplier shall provide instrument technicians and other support personnel for the purpose of start up and testing of the system.

B. Provide complete functional testing.

3.03 POINTS

A. Include the Owners standard point list.

END OF SECTION

SECTION 40 90 40 - PROGRAMMING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Contractor Responsibilities

1. Provide, install and configure all hardware.

2. Test and demonstrate all hardware.

3. Provide assistance during testing and demonstration as may be required.

B. Owners Responsibilities

1. All radio, PLC and SCADA programming shall be provided by the Owner.

PART 2 – PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION

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SECTION 40 97 00.1 - VARIABLE FREQUENCY DRIVE

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Provide a complete U.L. listed Variable Frequency Drive (VFD) system as specified within and as indicated on the drawings. System shall be provided complete with all necessary accessories and appurtenances as required for a completely functional system ready for immediate use.

B. Units shall be provided as specified below and with additional requirements as indicated on the drawings.

C. Like items of equipment provided hereunder shall be the end products of one manufacturer in order to achieve standardization for appearance, operation and maintenance.

D. See CONDITIONS OF THE CONTRACT and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the Work specified herein and are mandatory for this project.

E. Drive shall be provided as units by the specified manufacturer.

F. Units shall include custom engineering unique to this project.

G. Integrate pump protective equipment into the drive. Coordinate with the pump vendor.

H. Drives shall be for use on single phase supply and provide 3 phase output.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the General Requirements. Provide a minimum of six (6).

B. Fully Engineered shop drawings specific for this project shall be submitted to the ENGINEER for review and comment. Vendor shall clearly indicate his conformance to the requirements of this specification. Along with standard literature, a detailed schematic and assembly drawings shall be provided. A recommended statement shall be provided. Vendor shall not release the unit for manufacture without approved shop drawings.

C. Complete set of Operation and Maintenance Manuals shall be submitted in accordance with General Requirements.

D. Warranty information shall be submitted in accordance with the General Requirements.

E. Provide as built drawings in acad.dwg format.

1.03 QUALITY ASSURANCE

A. All equipment furnished under this specification shall be new and unused, shall be the product of a manufacturer having a successful record of manufacturing and servicing the equipment specified herein for a minimum of five (5) years.

1.04 WARRANTIES

A. Provide a full warranty covering labor, materials and services of a factory authorized technician including all expenses for a period of one (1) year, to begin after OWNER's start-up and acceptance of the drive. During this period, manufacturer shall repair any failures associated with the drive.

1.05 MANUFACTURERS

A. Manufacturers shall be limited to the following:

1. Square D.

2. No equal.

PART 2 – PRODUCTS

2.01 VARIABLE FREQUENCY DRIVE (VFD)

A. Provide a separate fully engineered Variable Frequency Drive (VFD) system for use with the pump/motor shown on plans.

1. Minimum drive inverter amps of output shall not be less than the amps as listed in Table 430-150 of the National Electrical Code, Latest Edition.

2. Minimum drive overload capability shall not be less than 110 percent of the output rated amps for 60 seconds.

3. Coordinate with pump requirements. Provide unit that meets amps, speed and torque requirements.

4. Drives shall be oversized. The rating of the drive shall be 125% of that which is indicated.

5. Coordinate with vendors and equipment suppliers regarding constant or variable torque applications and RPM of the driven loads. Provide units per applications.

B. As a minimum, include the following features:

1. Exterior front cabinet door mounted equipment shall be as follows:

   a. Hand-Off-Auto selector switch.

   b. Programmer/Monitor/Display Module and required appurtenances. Display shall indicate speed in percent.

   c. Engraved legend plate shall be provided for all devices.

   d. Run time meter hours, non-resettable, Electro-Mechanical Engler 200 Series or an approved equal.

2. Drive shall be provided with the capabilities to ride through brown outs and to restart on power loss and return after time delay.

3. Discrete output contacts shall be provided and wired to labeled terminal strip. Contacts shall be required as indicated per plans; one form "C" contact shall be provided. Additional slave relays shall be provided as required.

4. Provisions to receive a 4-20 mADC signal for remote speed. Signal isolation shall be provided in the drive.

5. Provision to send a 4-20 MADC signal to indicate speed.

6. Provision to send a 4-20 MADC signal to indicate motor amps.

7. Joslyn lightning arrestors, Surgitron, 1454-01 or an approved equal wired to the line side of the disconnect.

8. Six (6) spare fuses of each size and type used shall be provided.

9. Provide all labor and material for a complete and functional system. Such items include, but shall not be limited to:

   a. I/O

   b. Drivers

   c. Programming

   d. Setup

10. Units shall meet or exceed the requirements of IEEE 519. Provide additional labor and materials as may be required. Submit calculations for review and approval.
11. Provide cooling fans mounted in the door to exhaust heat towards the face of the drive.

C. Operation

1. Hand-Off-Auto mode selector

a. Discrete control

(i) Hand: The drive ramps up to the speed reference per the local potentiometer setting.

(ii) Off: Drive ramps down and no power is applied to the motor. While in the off position, the drive is no permitted to run.

(iii) Auto: Drive start/stop control is from the remote control panel. Upon receiving a start command, the drive ramps up to the remote speed reference. Upon receiving the stop command, the drive shall ramp down to zero output.

b. Speed control

(i) The speed reference shall be from the local potentiometer or keypad while the local H-O-A is in the hand mode and from the speed command word signal while in the automatic mode.

(ii) Adjustable minimum and maximum speed settings shall be provided.

(iii) Separate adjustable ramp slopes settings shall be provided for both acceleration and deceleration.

D. Output filters

1. Provide output filters, Transcoil or equal.

2. All units shall be provided with output filters.

2.02 VFD DESIGN

A. General

1. Supplier shall construct the drive to properly control internal and external equipment. No attempt is made to specify or indicate on drawings all required equipment, but rather to set forth the minimum requirements.

B. Engineering

1. Supplier shall provide system engineering and produce detailed fully engineered, coordinated and completed drawings.

C. Construction

1. Drive construction shall be per these specification and drawings.

PART 3 – EXECUTION

3.01 GENERAL

A. Install equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance.

B. Coordinate work with the OWNER, the CONTRACTOR and work of other trades to avoid conflicts, errors, delays and unnecessary interference with operation of the existing plant during construction.

C. Follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between manufacturers' instructions, and these Contract Documents, follow ENGINEER's decision, at no additional cost to the OWNER. Keep a copy of manufacturers' instructions on the jobsite available for review at all times.

3.02. MANUFACTURER'S SERVICES

A. Provide the services of a factory authorized service technician to start up, test and place in service the unit. This service shall be extended, as required, at the manufacturer's expense, if problems arise with the drive unit.

B. Provide separate from the start up, one (1) man day of training. This time shall be at the convenience of the OWNER. Minimum training instructions shall include the following:

1. Routine Maintenance

2. Programming, including entering the programming mode, changing set points interpreting fault information.

3. Trouble shooting

4. Fault corrections and resetting actions.

C. Programming

1. Program VFD features per project requirements.

2. Provide typewritten listing of final parameter setting with O&M manuals.

3.03 CLEAN-UP

A. Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove materials, scraps and debris from premises and from interior and exterior of all devices and equipment. Touch-up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency and type of surface of the original finish.

END OF SECTION