Northern Kentucky Water District
2835 Crescent Springs Road
Erlanger, KY 41018

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PUBLIC SERVICE
COMMISSION

PROJECT MANUAL VOL. 3

TECHNICAL SPECIFICATIONS OF THE CONTRACT (DIVISION 30-49)

for the construction of the

Fort Thomas Treatment Plant Advanced Treatment

Contract No. 184-447

STATE OF KENTUCKY
N. ED WINNIKE
18916
LICENSED
PROFESSIONAL ENGINEER

STATE OF KENTUCKY
Brent Alan Tippey
19651
LICENSED
PROFESSIONAL ENGINEER
11/9/09

CH2M HILL

300 E-Business Way, Suite 400
Cincinnati, Ohio 45241

HDR/Quest

2517 Sir Barton Way
Lexington, Kentucky 40509

December 1, 2009

Project No. 380723

Copy No.____________________

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SECTION 31 10 00
SITE CLEARING

PART 1 GENERAL

1.01 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2-inch caliper to a depth of 12 inches below subgrade.

D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.

E. Stripping: Removal of topsoil remaining after applicable scalping is completed.

F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.02 SUBMITTALS

A. Action Submittals: Drawings clearly showing clearing, grubbing, and stripping limits.

1.03 QUALITY ASSURANCE

A. Obtain Engineer's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.04 SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of one (1) acre.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or Site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.02 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation Excluding Trenches: 5 feet beyond top of cut slopes.
2. Trench Excavation: 4 feet from trench centerline, regardless of actual trench width.
3. Fill:
    a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
    b. Stripping and Scalping: 2 feet beyond toe of permanent fill.
4. Waste Disposal:
    a. Clearing: 10 feet beyond perimeter.
    b. Scalping and Stripping: Not required.
    c. Grubbing: Around perimeter as necessary for neat finished appearance.
5. Structures: 15 feet outside of new structures.
6. Roadways: Clearing in areas noted on plans
7. Overhead Utilities:
    a. Clearing and Grubbing: Entire width of easements and rights-of-way.
    b. Scalping and Stripping: Wherever grading is required.
8. Reservoir Area:
    a. Clearing: Not required
    b. Grubbing: Not required, except within borrow areas.
9. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 TEMPORARY REMOVAL OF INTERFERING PLANTINGS

A. Remove and store, as specified in MP-C-107 that are not designated for removal but do interfere with construction or could be damaged by construction activities.

B. Photograph and document location, orientation, and condition of each plant prior to its removal. Record sufficient information to uniquely identify each plant removed and to assure accurate replacement.

3.04 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing flush with ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.05 GRUBBING

A. Grub areas within limits shown or specified.

3.06 SCALPING

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.

B. Scalp areas within limits shown or specified.

3.07 STRIPPING

A. Do not remove topsoil until after scalping is completed.

B. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

C. Stockpile strippings, meeting requirements of Section 32 91 13, Soil Preparation, for topsoil, separately from other excavated material.

3.08 MERCHANTABLE TIMBER

A. Saleable logs will remain property of Owner.

B. Exercise care in cutting and felling to prevent damage to saleable logs. Cut, trim, and handle logs in such manner that will ensure best sale value.

C. Cut logs in increments of 2 feet between minimum length of 8 feet and maximum length of 24 feet, plus 8 inches for trim. Cut limbs off flush with trunks. Saleable logs shall each have a minimum top diameter of 8 inches, and minimum of 50 board feet.

D. Stockpile saleable logs in neat, orderly piles identified by the Owner.

3.09 TREE REMOVAL OUTSIDE CLEARING LIMITS

A. Remove Within Project Limits:

1. Dead, dying, leaning, or otherwise unsound trees that may strike and damage Project facilities in falling.
2. Trees designated by Owner.

B. Cut stumps off flush with ground, remove debris, and if disturbed, restore surrounding area to its original condition.

3.10 TREE TOPPING

A. Top trees adjacent to Project rights-of-way and easements for overhead utilities so remaining portion will not strike facilities in falling. Where topping will remove more than 1/2 of a tree's crown, remove entire tree.

B. Treat wounds resulting from topping as specified in MP-C-107.

3.11 PRUNING

A. Remove branches below the following heights:

1. 20 feet above roadways and shoulders.
2. 9 feet above sidewalks.
3. 6 feet above roofs.

B. Prune as specified in MP-C-107.

3.12 SALVAGE

A. Saleable log timber may be sold to Contractor's benefit. Promptly remove from Project Site.

B. Sod with commercial value may be sold to Contractor's benefit. Promptly remove from Project Site.

3.13 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris offsite.
2. Debris may be buried in designated onsite disposal areas to minimum depth of 3 feet below final grade. In lieu of onsite burial, dispose of debris offsite.
3. Burning of debris onsite will not be allowed.

4. When onsite burning is not prohibited by federal, state, or local authorities, debris may be burned onsite. Control burning to prevent fire from spreading.
5. During periods when burning is prohibited by federal, state, or local authorities, debris may be stockpiled until burning ban is rescinded, provided stockpiled material does not constitute a fire hazard or interfere with or delay Work. Stockpiled material shall not remain onsite in excess of 30 days.
6. Dispose of unburned and noncombustible debris offsite.
7. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

B. Scalpings: As specified for clearing and grubbing debris.

C. Strippings:

1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil offsite or in waste disposal areas shown.
2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

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SECTION 31 23 13
SUBGRADE PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3 (600 kN-m/m^3)).
   b. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   c. Thelen Associates - Report of Geotechnical Exploration , Advanced Treatment Building, Memorial Parkway Treatment Plant, May 2009

1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

D. Relative Density: As defined in Section 31 23 23, Fill and Backfill.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02 41 00, Demolition; 31 10 00, Site Clearing; and 31 23 16, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE

A. Notify Engineer when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION

A. Under Earthfill: Three passes with three-wheeled power roller weighing approximately 10 tons.

B. Under Earthfill: Compact upper 12 inches to minimum of 100 percent relative compaction as determined in accordance with ASTM D698 Standard Proctor Test.

C. Under Pavement Structure, Floor Slabs On Grade, or Granular Fill Under Structures: Two passes with a loaded dump truck or similar heavy-wheeled vehicle, in the presence of the CCA or Engineer to assure soils are firm and non-yielding . Any soils not seen as firm and non-yielding will be removed and replaced.

D. Under Pavement Structure, Floor Slabs On Grade, or Granular Fill Under Structures: Compact the upper 12 inches to minimum of 100 percent relative compaction as determined in accordance with ASTM D698, Standard Proctor Test. This shall be done prior to placing covering material.

3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.04 TESTING

A. Proof-roll subgrade with equipment specified in Article Compaction to detect soft or loose subgrade or unsuitable material, as determined by Engineer.

3.05 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or
2. Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

B. Unsuitable Material: Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

END OF SECTION

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SECTION 31 23 16
EXCAVATION

PART 1 GENERAL

1.01 DEFINITIONS

A. Common Excavation: All excavation is unclassified and cove.

1.02 SUBMITTALS

A. Informational Submittals:

1. Excavation Plan, Detailing:
   a. Methods and sequencing of excavation.
   b. Proposed locations of stockpiled excavated material.
   c. Proposed onsite and offsite spoil disposal sites.
   d. Dust control procedures for excavation and hauling.

1.03 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.04 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.05 SEQUENCING AND SCHEDULING

A. Demolition: Complete applicable Work specified in Section 02 41 00, Demolition, prior to excavating.

B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 10 00, Site Clearing, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.

D. Excavation Support: Install and maintain, as specified in Section 31 41 00, Shoring, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

3.02 UNCLASSIFIED EXCAVATION

A. All excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered without additional compensation when rock is encountered..

3.03 TRENCH WIDTH

A. Minimum Width of Trenches:

1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
   a. Less than 4-inch Outside Diameter or Width:18 inches.
   b. Greater than 4-inch Outside Diameter or Width:18 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
3. Increase trench widths by thicknesses of sheeting.

B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.04 PIPE BEDDING GROOVES FOR NONPERFORATED DRAIN LINES

A. Semicircular, trapezoidal, or 90-degree-V.

B. Excavated or plowed into trench bottom. Forming groove by compaction will not be acceptable.

3.05 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

3.06 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.07 DISPOSAL OF SPOIL

A. Unless otherwise directed by the Owner, dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, offsite.

B. Dispose of debris resulting from removal of underground facilities as specified in Section 02 41 00, Demolition, for demolition debris.

C. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 10 00, Site Clearing, for clearing and grubbing debris.

3.08 DUST CONTROL

A. Dust shall be controlled to preclude nuisance conditions and impairment of treatment plant functions, particularly water quality laboratory functions.

B. Dust control procedures shall be implemented during all excavation and hauling activities as described in the Excavation Plan submitted.

END OF SECTION

SECTION 31 23 19.01
DEWATERING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Water control plan.
2. Well permits.
3. Discharge permits.
4. Water Level Elevations Observed in Observation Wells: Submit same day measured.
5. Settlement Benchmark Elevations: Submit weekly record.
6. Inflow Measurements: Submit weekly record.

1.02 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
2. Drawings showing locations, dimensions, and relationships of elements of each system.
3. Design calculations demonstrating adequacy of proposed dewatering systems and components.

B. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

B. Remove and control water during periods when necessary to properly accomplish Work.

3.02 SURFACE WATER CONTROL

A. See Section 01 50 00, Temporary Facilities and Controls, Article Temporary Controls.

B. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. For dewatering systems shall include wells or well points, and other equipment and appurtenances installed outside structural limits and sufficiently below lowest point of excavation, or to maintain specified groundwater elevation.

C. Design and Operate Dewatering Systems:

1. To prevent loss of ground as water is removed.
2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
3. To relieve artesian pressures and resultant uplift of excavation bottom.

D. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

E. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

F. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering.

3.04 SETTLEMENT

A. Monitoring Dewatering-Induced Settlement: Establish monuments for monitoring settlement at locations selected by Engineer. Monitor vertical movement of each settlement monument, relative to remote benchmark selected by Engineer, at least weekly.

3.05 MONITORING FLOWS

A. Monitor volume of water pumped per calendar day from excavations, as Work progresses. Also monitor volume of water introduced each day into excavations for performance of Work. Monitor flows using measuring devices acceptable to Engineer.

3.06 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

3.07 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but not limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

3.08 REMEDIATION OF GROUNDWATER DEPLETION

A. If dewatering reduces quantity or quality of water produced by existing wells, temporarily supply water to affected well owners from other sources. Furnish water of a quality and quantity equal to or exceeding the quality and quantity available to well owner prior to beginning the Work or as satisfactory to each well owner.

3.09 SHALE ISOLATION

A. If free-flowing groundwater is encountered within the trench that may come in routine and consistent contact with low moisture shale formation, Contactor will take measures as needed to prevent swelling associated with the shale.

END OF SECTION

SECTION 31 23 23
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
   e. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   f. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   g. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   h. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   i. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   j. Thelen Associates - Report of Geotechnical Exploration , Advanced Treatment Building , Memorial Parkway Treatment Plant, May 2009

1.02 DEFINITIONS

A. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.

B. Optimum Moisture Content:

 1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
 2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:

 1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
 2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
 3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:

 1. 1 foot outside outermost edge at base of foundations or slabs.
 2. 1 foot outside outermost edge at surface of roadways or shoulder.
 3. 0.5 foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

K. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.

L. Imported Material: Materials obtained from sources offsite, suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Tank manufacturer's recommendations for backfill around each buried tank.
2. Samples:
    a. Imported material taken at source.

B. Informational Submittals:

1. Manufacturer's data sheets for compaction equipment.
2. Certified test results from independent testing agency.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Structure or tank is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

1.05 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition; Section 31 10 00, Site Clearing; Section 31 23 16, Excavation; and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.

B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, Cast-in-Place Concrete. Obtain Engineer's acceptance of concrete work and attained strength prior to placing backfill.

C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, Cast-in-Place Concrete.

D. Backfill around buried tanks only after tank is set in position, securely anchored, and ready to be backfilled and Engineer provides authorization to backfill.

E. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.

PART 2 PRODUCTS

2.01 EARTHFILL

A. Excavated material from required excavations and designated borrow sites, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Material containing more than 10 percent gravel, stones, or shale particles must be approved for use by Engineer.

C. Provide imported material of equivalent quality, if required to accomplish Work.

2.02 GRANULAR FILL

A. 1-inch minus crushed gravel or crushed rock.

B. Free from dirt, clay balls, and organic material.

C. Well-graded from coarse to fine and containing sufficient fines to bind material when compacted, but with maximum 8 percent by weight passing No. 200 sieve.

2.03 SAND

A. Free from clay, organic matter, or other deleterious material.

B. Gradation as determined in accordance with ASTM C117 and ASTM C136:

Sieve Size	Percent Passing by Weight
1/4-inch	100
No. 4	95 - 100
No. 200	0 - 8

2.04 FLOWABLE FILL

A. Portland Cement lean concrete with a 28-day compressive strength of 1,500 psi.

B. Slump shall not exceed 8'

2.05 GRANULAR DRAIN MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

2.06 GRANULAR FILTER MATERIAL

A. Clean, hard, durable gravel, free from foreign materials and washed.

B. Gradation as determined in accordance with ASTM C117 and ASTM C136:

2.07 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.08 BASE COURSE ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.09 FOUNDATION STABILIZATION ROCK

A. Crushed rock or pit run rock.

B. Uniformly graded from coarse to fine.

C. Free from excessive dirt and other organic material.

D. Maximum 2-1/2-inch particle size.

2.10 SOIL COVER OVER GEOTEXTILES

A. Particle Size: Maximum **1** inch.

B. Free of sharp angular pieces that may damage geotextile.

2.11 SOIL COVER OVER GEOMEMBRANES

A. Granular material.

B. Particle Size: Maximum 1/4 inch.

C. Particle Shape: Rounded.

PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable, as specified in Section 31 23 23.15, Trench Backfill.
4. Install item.
5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.15, Trench Backfill, before resuming filling or backfilling specified in this section.

F. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1 foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise shown. Place granular fill in lifts of 6-inch maximum thickness and compact each lift to minimum of 95 percent relative compaction . in accordance with ASTM D698.

B. Subsurface Drainage: Backfill with compacted, free draining granular material with less than 3% material passing the No. 200 sieve. Place granular drain material in lifts of 6-inch maximum thickness and compact each lift to minimum of 95%of the Standard Proctor Maximum Dry Density (ASTM 698). All surface drainage material must be capped with a 2'-0" thick compacted clay cap. The clay must be separated from the granular material with a non-woven geotextile fabric specifically designed for filtration.. The same geotextile fabric is required between the subsurface drainage material and the surrounding bedrock.(limestone or shale).

C. Other Areas: Backfill with earthfill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 95 percent relative compaction as determined in accordance with ASTM D698,.

D. Flowable fill: All backfill below the drain invert level shall consist of lean concrete.

3.03 BACKFILL AROUND TANKS

A. Backfill to top of tank, unless otherwise shown, with granular fill and thoroughly water settle by saturating backfill and vibrating saturated backfill with a concrete vibrator inserted through full depth of backfill on 1-foot maximum centers.

B. Backfill above top of tank with earthfill placed in 8-inch lifts. Compact each lift to minimum95 percentlative compaction as determined in accordance with ASTM D98.

3.04 FILL

A. Outside Influence Areas beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities: Unless otherwise shown, place earthfill as follows:

1. Allow for 6-inch thickness of topsoil where required.
2. Maximum 8-inch thick lifts.
3. Place and compact fill across full width of embankment.

4. Compact to minimum 95 percent relative compaction as determined in accordance with ASTM D698.
5. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

3.05 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.
2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet Specification requirements.

B. In-Place Density Tests: In accordance with ASTM D556 During placement of materials, test as follows:

1. Granular Fill:
2. Sand:
3. Backfill Around Buried Tanks:
4. Granular Drain Material:
5. Granular Filter Material:
6. Base Course Rock:
7. Foundation Stabilization Rock:
8. Soil Cover Over Geotextiles:
9. Soil Cover Over Geomembranes:

3.06 SAND BLANKET OVER VAPOR RETARDER

A. Place sand in manner that avoids damage to underlying vapor retarder.

B. Moisten sand and thoroughly compact it with a vibratory plate compactor.

3.07 GRANULAR BASE, SUBBASE, AND SURFACING

A. Place and Compact as specified in Section 32 11 23, Aggregate Base Courses.

3.08 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Engineer as follows:

1. Beneath Footings: Concrete or flowable fill as directed by the Engineer.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
3. Beneath Slabs-On-Grade: Granular fill.
4. Trenches:
   a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.15, Trench Backfill.
   b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.15, Trench Backfill.
5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
   a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
   b. Steep Slopes (Steeper than 3:1):
      1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
      2) Backfilling overexcavated areas is prohibited, unless in Engineer's opinion, backfill will remain stable, and overexcavated material is replaced as compacted earthfill.

3.09 PLACING FILL OVER GEOSYNTHETICS

A. General:

   1. Place fill over geosynthetics with sufficient care so as not to damage them.
   2. Place fill only by back dumping and spreading only.
   3. Dump fill only on previously placed fill.
   4. While operating equipment, avoid sharp turns, sudden starts or stops that could damage geosynthetics.

B. Hauling: Operate hauling equipment on minimum of 3 feet of covering.

C. Spreading:

   1. Spreading equipment shall be track mounted low ground pressure, D-6 or lighter.
   2. Operate spreading equipment on minimum of 12 inches of fill over geosynthetics.
   3. Spread fill in same direction as unseamed overlaps to avoid separation of seams and joints.

4. Never push fill downslope. Spread fill over sideslopes by pushing up from slope bottom. access to bottom of slope is unavailable, progressively place fill, beginning at toe of slope and working upslope, with backhoe or dragline operated from top of slope. Limit distance material falls onto the geosynthetics to maximum of 2 feet.
5. Geotextiles, Correct wrinkles in geotextiles.
6. Maintain proper overlap of unseamed geosynthetics.
7. Avoid overstressing geosynthetics and seams.

D. Compaction: Compact fill only after uniformly spread to full thickness shown.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to geosynthetics, so repairs may be made.
2. Clear overlying fill as necessary to repair damage.
3. Repairs to geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.

END OF SECTION

SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Public Works Association (APWA): Uniform Color Code for Temporary Marking of Underground Utility Locations.
2. ASTM International (ASTM):
   a. C33, Standard Specification for Concrete Aggregates.
   b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. C150, Standard Specification for Portland Cement.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
   g. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
   h. D1140, Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 micrometer) Sieve.
   i. D1557, Standard Test Method for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   j. D3776, Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.
   k. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   l. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   m. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   n. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   o. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.

p. D4991, Standard Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method.
q. D5034, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).

3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Color Code.

1.02 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either as-compacted field dry density or maximum dry density, as determined by Engineer.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

I. Selected Backfill Material: Material available onsite that Engineer determines to be suitable for a specific use.

J. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer's descriptive literature for marking tapes.
2. Samples:
   a. Trench stabilization material.
   b. Bedding and pipe zone material.
   c. Granular drain.
   d. Granular backfill.
   e. Earth backfill.
   f. Sand(s).
   g. Geotextile.

B. Informational Submittals:

1. Catalog and manufacturer's data sheets for compaction equipment.
2. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.
3. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 PRODUCTS

2.01 MARKING TAPE

A. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
4. Width: 3 inches.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
   a. Reef Industries; Terra Tape, Sentry Line Detectable.
   b. Mutual Industries; Detectable Tape.
   c. Presco; Detectable Tape.

B. Color: In accordance with APWA Uniform Color Code for Temporary Marking of Underground Facilities.

Color*	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code.	

2.02 TRENCH STABILIZATION MATERIAL

A. All process yard piping shall be laid on a bed of granular material except when a concrete encasement situation occurs. All pipe bedding material shall be No. 57 crushed stone aggregate and shall be placed to a depth of 4 inches in an earth trench and 6 inches in a rock trench. Aggregate bedding shall be graded to provide a uniform and continuous support beneath the pipe at all points.

B. The trench bottom for process yard piping shall be stable, continuous, relatively smooth and free of frozen material, clodded dirt, foreign material and rock or granular material larger than ½-inch in diameter. The foundation for piping shall be prepared so that the entire load of the backfill on top of the pipe will be carried uniformly on the barrel of the pipe. Any uneven areas in the trench bottom shall be shaved off or filled in with granular bedding. When the trench is made through rock, the bottom shall be lowered to provide 6 inches of clearance around the pipe. Granular bedding shall be used to bring the trench bottom to grade.

1. Clean gravel or crushed rock, reasonably well-graded from coarse to fine.
2. Maximum Particle Size: 1-inch.
3. Dry sand, accepted by Engineer, may be provided for trenches above maximum groundwater level.

2.03 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified. Crushed stone to be compacted to 85% relative density.

1. Duct Banks: 3/4-inch maximum particle size.
2. PVC Irrigation System Piping and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
3. Perforated Pipe: Granular drain material.
4. Conduit and Direct-Buried Cable:
    a. Sand, clean or clean to silty, less than 12 percent passing No. 200 sieve.
    b. Individual Particles: Free of sharp edges.
    c. Maximum Size Particle: Pass a No. 4 sieve.
    d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

2.04 EARTH BACKFILL

A. Soil, loam, or other excavated material suitable for use as backfill.

B. Free from roots or organic matter, refuse, boulders and material larger than 1/2 cubic foot, or other deleterious materials.

2.05 PROCESSED EARTH BACKFILL

A. Class A Backfill: Earth backfill, meeting the following additional requirement.

1. Free of boulders and cobbles that would be retained on a [3-inch sieve.
2. Placed in 6 to 8-inch lifts and compacted to 95% maximum dry density in accordance with ASTM D698.

2.06 CONTROLLED LOW STRENGTH FILL

A. Select and proportion ingredients to obtain compressive strength between 50 and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:

1. Cement: ASTM C150, Type I or Type II.
2. Aggregate: ASTM C33, Size 7.
3. Fly Ash (if used): ASTM C618, Class C.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.07 CONCRETE BACKFILL

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

B. Mix: ASTM C94/C94M, Option A.

1. Cement: ASTM C150, Type I or Type II.
2. Coarse Aggregate Size:1-1/2 inch(es).
3. Design for Minimum Compressive Strength at 28 Days: 2,500 psi.

2.08 GRAVEL SURFACING ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.09 TOPSOIL

A. As specified in Section 32 91 13, Soil Preparation.

2.10 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 for:

1. Earth backfill, including specified class.
2. Trench stabilization material.
3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs:

1. Controlled low strength fill.
2. Concrete.

PART 3 EXECUTION

3.01 TRENCH PREPARATION

A. Water Control:

1. As specified in Section 31 23 19.01, Dewatering.
2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.02 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Engineer. Engineer will determine depth of overexcavation, if any required.

3.03 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material.

B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

3.04 BEDDING

A. Furnish imported bedding material where, in the opinion of Engineer, excavated material is unsuitable for bedding or insufficient in quantity.

B. Place over the full width of the prepared trench bottom in two equal lifts when the required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum Thickness: As follows:

1. Pipe 15 Inches and Smaller: 4 inches.
2. Pipe 18 Inches to 36 Inches: 6 inches.
3. Pipe 42 Inches and Larger: 8 inches.
4. Conduit: 3 inches.
5. Direct-Buried Cable: 3 inches.
6. Duct Banks: 3 inches.

E. Check grade and correct irregularities in bedding material. Loosen top 1 inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.05 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:

1. Pipe: 12 inches, unless shown otherwise.
2. Conduit: 3 inches, unless shown otherwise.
3. Direct-Buried Cable: 3 inches, unless shown otherwise.
4. Duct Bank: 3 inches, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2 pipe diameter.
2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by "walking in" and slicing material under haunches with a shovel to ensure that voids are completely filled before placing each succeeding lift.

E. After the full depth of the pipe zone material has been placed as specified, compact the material by a minimum of three passes with a vibratory plate compactor only over the area between the sides of the pipe and the trench walls.

F. Do not use power-driven impact compactors to compact pipe zone material.

3.06 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of all buried piping, on top of last lift of pipe zone material. Coordinate with piping installation drawings.

1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.
2. Nondetectable Marking Tape: Install with metallic piping.

3.07 BACKFILL ABOVE PIPE ZONE

A. General:

1. Process excavated material to meet specified gradation requirements.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into the trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over the top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench unless otherwise shown or specified.

B. Class A Backfill:

1. Place in lifts not exceeding thickness of 9 inches.
2. Mechanically compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

C. Class A Backfill:

1. Place in lifts of suitable thickness.
2. Mechanically compact each lift prior to placing succeeding lifts.
3. Determine proper lift thickness, type of compaction equipment, method to use, and amount of compaction necessary to prevent settlement.

D. Class C Backfill:

1. Backfill with earth backfill.
2. Leave trench with backfill material neatly mounded across the entire trench width, but not more than 6 inches above the adjacent ground surface.
3. In lawn, garden, or similar type areas, maintain trench level with the existing adjacent grade.
4. At Other Locations:
    a. Estimate and provide amount of backfill material required so that after normal settlement, the settled surface will match the adjacent ground surface.
    b. Neatly windrow material over trench, and remove excess.
    c. Correct excess or deficiency of backfill material apparent after settlement and within correction period by regrading, and disposing of excess material or adding additional material where deficient.

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SECTION 31 32 00
SOIL STABILIZATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D3776, Standard Test Method for Mass Per Unit Area (Weight) of Fabric.
   b. D4355, Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
   c. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

1.02 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted and continue for a period of 8 weeks after all planting under this section is completed.

B. Satisfactory Stand: Grass or section of grass of 10,000 square feet or larger that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.03 SUBMITTALS

A. Action Submittals: Product data for commercial products.

B. Informational Submittals:

1. Subschedule of drainage, erosion, and sedimentation control.
2. Construction Period Drainage and Erosion/Sedimentation Control Plan and Procedures.
3. Manufacturer's Installation Instructions: Commercial products.
4. Seed certifications.

5. Copies of delivery invoices or other proof of quantities of mulch and fertilizer.

1.04 DELIVERY, STORAGE, AND PROTECTION

A. As specified in Section 32 92 00, Turf and Grasses.

B. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

C. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.05 SEQUENCING AND SCHEDULING

A. Engineer's acceptance of Construction Period Erosion/Sedimentation Control Plan required prior to starting earth disturbing activities.

B. As specified in Section 32 92 00, Turf and Grasses.

C. Prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.

D. Complete soil preparation, seeding, fertilizing, mulching and matting within 30 days after final grades have been reached.

E. Notify Engineer at least 7 days in advance of:

1. Materials delivery.
2. Start of planting activity.

F. Seeding: Perform under favorable weather conditions during seasons that are normal for such Work as determined by accepted local practice.

1.06 MAINTENANCE

A. Operations:

1. As specified in Section 32 92 00, Turf and Grasses. Perform during maintenance period to include:
   a. Watering: Keep seeded surface moist.
   b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.

c. Mulch: Replace wherever and whenever washed or blown away.
d. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
e. Reseed during next planting season if scheduled end of maintenance period falls after September 15..

2. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.
3. Inspect, repair, and replace as necessary all erosion control measures during the time period from start of construction to completion of construction.

PART 2 PRODUCTS

2.01 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose. Confirm recommended material composition with county extension agent.

2.02 SEED

A. As specified in Section 32 92 00, Turf and Grasses.

B. Summer Mix:

1. As recommended by county extension agent or local authorities.

2.03 MULCH

A. Wood Cellulose Fiber Mulch:

1. Specially processed wood fiber containing no growth or germination inhibiting factors.
2. Dyed a suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

B. Straw:

1. As specified in Section 32 92 00, Turf and Grasses.
2. Average Stalk Length: 6 inches.
3. Seasoned before baling or loading.

2.04 EROSION CONTROL MATTING

A. Matting as specified in Section 32 92 00, Turf and Grasses.

B. Manufacturers and Products:

1. Akzo Industries, Asheville, NC; Curlex Mat.
2. North American Green, Evansville, IN; S150 blanket.

2.05 REINFORCED PLASTIC COVERING

A. Co-extruded, copolymer laminate reinforced with nonwoven grid of high strength nylon cord submersed in a permanently flexible adhesive media allowing for equal tear resistance in all directions.

B. Black in color and ultraviolet stabilized.

C. Physical Requirement (Minimum Average Roll Values):

1. Tear Strength: 130 pounds.
2. Elongation: 620 percent.

D. Manufacturers:

1. Reef Industries, Inc., Houston, TX.
2. Griffolyn Co., Houston, TX.

2.06 CLEARING LIMIT FENCE

A. Ultraviolet stabilized polyethylene or polypropylene safety fence, 3 feet in height, and yellow or orange in color.

B. Pervious Sheet: Polyester, polypropylene, or nylon filaments, woven into a uniform pattern, distinct and measurable openings.

1. Filaments: Resistant to damage from exposure to ultraviolet rays and heat.
2. Material Edges: Finish so filaments retain their relative positions under stress.

C. In accordance with requirements of Table No. 1:

Table No. 1 - Filter Fence		
Physical Property	**Required Value**	**Test Method**
Weight, oz/sq yd, min.	4	ASTM D3776
Equivalent Opening Size, max.	50-70	U.S. Standard Sieve
Grab Tensile Strength, lb, min.	160	ASTM D4632
Ultraviolet Radiation Resistance, % Strength Retention	70	ASTM D4355

D. Manufacturers:

1. Polyfelt, Evergreen, AL.
2. Dupont Co., Wilmington, DE.
3. Mirafi, Inc., Charlotte, NC.

2.07 SUPPORT FENCE

A. Wire Mesh Material: As recommended by manufacturer of geotextile; strong enough to support applied loads.

B. Support Posts: As recommended by manufacturer of geotextile.

C. Fasteners: Heavy-duty wire staples at least 1 inch long, tie wires, or hog rings, as recommended by manufacturer of geotextile.

2.08 STRAW BALES

A. Machine baled clean salt hay or straw of oats, wheat, barley, or rye, free from seed of noxious weeds, using standard baling wire or string.

2.09 POSTS FOR STRAW BALES

A. 2-inch by 2-inch untreated wood or commercially manufactured metal posts.

PART 3 EXECUTION

3.01 SOIL PREPARATION

A. Before start of hydroseeding, and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.02 SEEDING

A. Prepare 1-inch deep seed bed; obtain Engineer's acceptance prior to proceeding.

B. Apply by hydroseeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.

C. Application in accordance with recommendations from county extension agent.

3.03 MULCHING

A. Apply uniformly on disturbed areas that will remain undisturbed for 7 days or more, as requested by Engineer, and on seeded areas with a slope steeper than 5 percent.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.

1. Straw: Apply by hand or mechanical means to minimum depth of 2 inches.
2. Wood Cellulose Fiber: 1,000 to 1,500 pounds per acre.

3.04 EROSION CONTROL MATTING

A. Place on seeded slopes 3H:1V and steeper, staple/stake in place and with the appropriate overlap in accordance with the manufacturer's instruction.

3.05 TACKIFIER

A. Apply on areas mulched with straw.

B. Spray on after mulch is in place.

C. Apply in quantities sufficient to equal retention properties of a CSS-1 asphalt emulsion being applied at rate of 400 gallons per acre.

3.06 REINFORCED PLASTIC COVERING

A. Place on areas where hydroseeding and erosion control matting have not controlled erosion.

B. Install in single thickness, strips parallel to direction of drainage.

C. Maintain tightly in place by using sandbags on ropes with a maximum 10-foot grid spacing in all directions.

D. Tape or weight down full length, overlap seams at least 12 inches.

E. Remove at final acceptance unless notified otherwise by Engineer.

3.07 CLEARING LIMIT FENCE

A. Install in accordance with manufacturer's standard instructions and before beginning clearing and grubbing operations.

3.08 SUPPORT FENCE AND GEOTEXTILE

A. Install prior to starting earth disturbing activities upslope of fence.

B. One-piece geotextile or continuously sewn to make one-piece geotextile for full height of the fence, including portion buried in the toe trench.

C. When joints are necessary, splice geotextile together only at a support post, with a minimum 6-inch overlap, and securely fasten both ends to support post.

D. Geotextile shall not extend more than 24 inches above the ground surface. Securely fasten to upslope side of each support post using ties. Geotextile shall not be stapled to existing trees.

E. Fasten wire mesh material support fence securely to upslope side of post fasteners. Extend wire into the trench a minimum of 4 inches, and not more than 36 inches above the ground surface.

F. Take precaution not to puncture geotextile during installation. Repair or replace damaged area.

G. Remove support fence for geotextile after upslope area has been permanently stabilized. Immediately dress sediment deposits remaining after the geotextile fence has been removed to conform to existing grade. Prepare and seed graded area.

3.09 SOIL STOCKPILES

A. Protect from erosion with geotextile and support fence.

3.10 STRAW BALES

A. Embed minimum of 4 inches in flat-bottomed trench.

B. Place with ends tightly abutting or overlapped. Corner abutment is not acceptable.

C. Install so that bale bindings are oriented around the sides and not over the top and bottom of the bale.

D. Use two posts for each bale. Drive posts through the bale until top of post is flush with top of bale.

E. Wedge loose straws in any gaps between bales.

3.11 FIELD QUALITY CONTROL

A. Upon completion of maintenance period and on written notice from Contractor, Engineer will within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Engineer will make another determination upon written notice from Contractor following the next growing season.

END OF SECTION

SECTION 31 37 00
RIPRAP

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   b. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. C150, Standard Specification for Portland Cement.
   d. C535, Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.02 DEFINITIONS

A. Refer to applicable definitions in Section 31 23 23, Fill and Backfill.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Description and location of proposed sources of riprap bedding and riprap.

B. Informational Submittals:

1. Certified Test Results:
   a. Riprap Bedding:
      1) Gradation.
      2) Abrasion resistance.
   b. Riprap:
      1) Gradation.
      2) Abrasion resistance.
      3) Bulk density.
2. Trip tickets showing source, type, and weight of each load of material delivered to Site.

1.04 QUALITY ASSURANCE

A. Riprap Source: Quarry that has produced riprap and has performed satisfactorily on other projects for at least 5 years.

B. Site Visit: Make arrangements for Engineer to visit quarry site to observe materials proposed for riprap and riprap bedding.

1.05 SCHEDULING AND SEQUENCING

A. Complete subgrade preparation as specified in Section 31 23 13, Subgrade Preparation, prior to placing riprap bedding or riprap.

PART 2 PRODUCTS

2.01 AGGREGATE RIPRAP BEDDING

A. Gravel with Cobbles or Crushed Rock with Cobble-Sized Pieces:

1. Gradation, as determined in accordance with ASTM C136:
   a. Well-graded from coarse to fine.
   b. All pieces pass a 6-inch square opening.
   c. Minimum 85 percent by weight passes 4-inch square opening.
   d. Minimum 10 percent by weight passes No. 4 U.S. standard sieve.
2. Abrasion Resistance: Maximum 35 percent wear when tested in accordance with ASTM C535.

B. Free of roots and other organic or deleterious matter.

C. Onsite material from excavations or designated borrow sources that meets or is processed to meet requirements specified above may be used as riprap bedding in lieu of importing material.

2.02 RIPRAP

A. Hard and durable quarry stone free from fractures, bedding planes, pronounced weathering, and earth or other adherent coatings.

B. Minimum Dimension of Individual Pieces: Not less than 1/3 maximum dimension.

C. Abrasion Resistance: Maximum 35 percent wear as determined in accordance with ASTM C535.

D. Bulk Density: Minimum 160 pounds per dry cubic foot.

E. Gradation: Smaller pieces shall generally fill voids between larger pieces without either excess or deficiency of one or more sizes of stone.

Class	Thickness (Inches)	Weight (Pounds)	% Greater Than
I	12	150 100 50 25	0 to 5 30 75 90
II	18	250 150 50 25	0 to 5 30 75 90
III	24	800 400 200 25	0 to 5 30 75 90
IV	30	1,600 800 400 50	0 to 5 30 75 90
V	36	2,700 1,600 800 100	0 to 5 30 75 90

2.03 CONCRETE GROUT

A. Portland cement concrete as specified in Section 03 30 00, Cast-in-Place Concrete, having a 28-day compressive strength of 3,000 psi.

2.04 CONCRETE GROUT

A. Mix: ASTM C94/C94M, Option A.

1. Cement: ASTM C150, Type I.
2. Coarse Aggregate Size: 1 inch.
3. Design for Minimum Compressive Strength at 28 Days: 2,500 psi.

PART 3 EXECUTION

3.01 PLACING RIPRAP

A. Place riprap over prepared subgrade to lines and grades shown.

B. No mechanical compaction of riprap is required; however, work riprap bedding as necessary to distribute it and to eliminate detrimental voids. Avoid overworking or long pushes that result in segregation of particle sizes.

C. Grade surface of riprap bedding free from irregularities and to tolerances of from established grade.

D. Place and grade riprap in a manner that avoids subgrade disturbance.

3.02 GROUTING RIPRAP

A. Remove dirt and foreign substances from surfaces of riprap and then moisten.

B. Deposit grout by means of chutes, tubes, or buckets, or place by means of pneumatic equipment or other mechanical methods. Place grout in a continuous operation for any day's run at any one location.

C. Limit flow distance of grout along slope to less than 10 feet.

D. Spade and rod grout into place with suitable spades, trowels, or other approved means immediately after depositing grout. Depths of grout shall be approximately 1/2 the thickness of the riprap.

E. Following placement of grout, thoroughly brush rocks so top surfaces are exposed. Outer rocks shall project 1/3 to 1/4 their diameter above grout surface. Brushing shall follow closely behind rodding such that grout shall not be in place more than 1 hour before brushing.

F. Once brushing of area is complete, no worker or load will be permitted on surface for period of at least 24 hours, or longer if so required by Engineer.

G. Cure grout as provided in Section 03 30 00, Cast-in-Place Concrete.

END OF SECTION

SECTION 31 41 00
SHORING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation support plan.
2. Movement monitoring plan.
3. Trench excavation plan.
4. Movement measurement and data and reduced results indicating movement trends.

1.02 QUALITY ASSURANCE

A. Provide surveys to monitor movements of existing facilities that are adjacent to new excavations.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work.

B. The design, construction and maintenance of necessary shoring is the sole responsibility of the contractor.

3.02 EXCAVATION SUPPORT PLAN

A. Prepare excavation support plan signed and sealed by a professional engineer licensed in the State of Kentucky addressing following topics:

1. Details of shoring, bracing, sloping, or other provisions for worker protection from hazards of caving ground.
2. Methods and sequencing of installing excavation support.
3. Proposed locations of stockpiled excavated material.
4. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.
5. Anticipated difficulties and proposed resolutions.

3.03 MOVEMENT MONITORING PLAN

A. Prepare movement monitoring plan addressing following topics:

1. Survey control.
2. Location of monitoring points.
3. Plots of data trends.
4. Interval between surveys.

3.04 REMOVAL OF EXCAVATION SUPPORT

A. Remove excavation support in a manner that will maintain support as excavation is backfilled.

B. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.

C. Remove excavation support in a manner that does not leave voids in the backfill.

3.05 TRENCHES

A. Provide trench excavations exceeding 4 feet in depth with adequate safety systems meeting the requirements of the Washington Industrial Safety and Health Act, Chapter 49.17 RCW.

B. For trench excavation exceeding 5 feet in depth, provide adequate safety system meeting requirements of California Labor Code Section 6707, applicable local construction safety orders, and federal requirements.

C. For trench excavation exceeding 5 feet in depth, provide adequate safety system meeting requirements of applicable state and local construction safety orders, and federal requirements.

END OF SECTION

SECTION 32 11 23
AGGREGATE BASE COURSES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
    a. T11, Standard Method of Test for Materials Finer Than 75µm (No. 200) Sieve in Mineral Aggregates by Washing.
    b. T27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
    c. T89, Standard Specification for Determining the Liquid Limit of Soils.
    d. T90, Standard Specification for Determining the Plastic Limit and Plasticity Index of Soils.
    e. T96, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
    f. T99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in) Drop.
    g. T180, Standard Specification for Moisture-Density Relations of Soils Using a 4.54 kg (10-lb) Rammer and a 457 mm (18-in) Drop.
    h. T190, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
    i. T265, Standard Method of Test for Laboratory Determination of Moisture Content of Soils.
    j. T310, Standard Specification for In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
2. ASTM International (ASTM):
    a. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
    b. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
    c. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
    d. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

1.02 DEFINITIONS

A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform cross-section thickness.

C. Standard Specifications: When referenced in this section, shall mean XX.

1.03 SUBMITTALS

A. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 10 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.

PART 2 PRODUCTS

2.01 BASE COURSE

A. No. 57 or No. 610 crushed stone as identified by the standard specifications for road and bridge construction as published by the Kentucky Transportation Cabinet.

2.02 LEVELING COURSE AND GRAVEL SURFACING

A. Where leveling or gravel surfacing is required, Contractor shall use No. 610 crushed stone with no more than 12% finer than a 200 sieve shall be used as detailed in standard specifications for road and bridge construction (latest edition) by the Kentucky Transportation Cabinet.

2.03 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. As specified in Section 31 23 13, Subgrade Preparation.

B. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

A. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Of uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

B. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway or prepared surface without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Untreated Aggregate Base Course:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.
5. Add keystone to achieve compaction and as required when aggregate does not compact readily due to lack of fines or natural cementing properties, as follows:

a. Use leveling course or surfacing material as keystone.
b. Spread evenly on top of base course, using spreader boxes or chip spreaders.
c. Roll surface until keystone is worked into interstices of base course without excessive displacement.
d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.

6. Blade or broom surface to maintain true line, grade, and cross-section.

B. Leveling Course:

1. Maximum Completed Lift Thickness: 4 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on roadway or preceding course to depth, grade, and cross-section shown.
4. Lightly blade surface and roll until thoroughly compacted to line and grade shown.
5. Maintain moisture levels to prevent loss of fines during processing.

C. Gravel Surfacing:

1. Maximum Completed Lift Thickness: 9 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on preceding course in accordance with cross-section shown.
4. Blade lightly and roll surface until material is thoroughly compacted.

3.05 ROLLING AND COMPACTION

A. Commence compaction of each layer of base after spreading operations and continue until density of 100 percent of maximum density has been achieved as determined by ASTM D698 or AASHTO T99.

B. Commence rolling at outer edges and continue toward center; do not roll center of road first.

C. Apply water as needed to obtain specified densities.

D. Place and compact each lift to required density before succeeding lift is placed.

E. Remove floating or loose stone from surface of preceding course before placing leveling course.

F. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

G. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.06 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate Base and Leveling Course: Within plus or minus 0.04 foot of grade shown at any individual point.

C. Gravel Surfacing: Within 0.04 foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

D. Overall Average: Within plus or minus 0.01 foot from crown and grade specified.

3.07 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Refer to Table 2 for minimum sampling and testing requirements for aggregate base course and surfacing.

Table 2
Minimum Sampling and Testing Requirements

Property	Test Method	Frequency	Sampling Point
Gradation	AASHTO T11 and AASHTO T27	One sample every 4 hours of production	Roadbed after processing
Moisture Density (Maximum Density)	AASHTO T99, Method D	One test for every aggregate grading produced	Production output or stockpile
In-Place Density and Moisture Content	AASHTO and AASHTO T265 for moisture content	One for each 500 ton but at least every 10,000 sq ft of area	In-place completed, compacted area

3.08 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

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SECTION 32 12 16
ASPHALT PAVING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M17, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
   b. M81, Standard Specification for Cut-Back Asphalt (Rapid Curing Type).
   c. M82, Standard Specification for Cut-Back Asphalt (Medium Curing Type).
   d. M140, Standard Specification for Emulsified Asphalt.
   e. M208, Standard Specification for Cationic Emulsified Asphalt.
   f. T166, Standard Method of Test for Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens.
   g. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
   h. T230, Standard Method of Test for Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures.
   i. T245, Standard Method of Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.
   j. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of Hveem Apparatus.
   k. T247, Standard Method of Test for Preparation of Test Specimens of Bituminous Mixtures by Means of California Kneading Compactor.
   l. T283, Standard Method of Test for Resistance of Compacted Bituminous Mixture to Moisture Induced Damage.
   m. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate (Method A).
2. Asphalt Institute (AI):
   a. Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete.
   b. Superpave Series No. 2 (SP-2), Superpave Mix Design.
3. ASTM International (ASTM):
   a. D2041, Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.

b. D4318, Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
c. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
d. D5821, Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
e. E329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

1.02 DEFINITIONS

A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.

B. RAP: Reclaimed asphalt pavement.

C. Standard Specifications: State of Kentucky 2008 Standard Specifications for Road and Bridge Construction

1.03 DESIGN REQUIREMENTS

A. Prepare asphalt concrete mix design, meeting the following design criteria, tolerances, and other requirements of this Specification.

B. Design Criteria:

1. Superpave Method, AI SP-2:
   a. Coarse Aggregate Angularity, ASTM D5821: One or more fractured faces 95 percent minimum; two or more fractured faces 75 percent, minimum.
   b. Fine Aggregate Angularity, AASHTO T304: 40 percent below 100 millimeters from surface and 40percent above 100 millimeters from surface.
   c. Flat and Elongated Particles, ASTM D4791: 10 percent, maximum.
   d. Clay Content, AASHTO T176: Minimum sand equivalent of 40 percent.
   e. Voids in Mineral Aggregate: See Table 1.
   f. Voids Filled with Asphalt: 65-75 percent.
   g. Mixture Density as a Percentage of Theoretical Maximum Density at Initial Gyration Level: 89 percent, maximum.
   h. Mix Density at Maximum Number of Gyrations: Less than 98 percent of theoretical maximum density.
   i. Dust Proportion: 0.8 to 1.6.
   j. Air Voids: 4 percent.
   k. Tensile Strength Ratio, AASHTO T283: 80 percent, minimum.

Table 1 **Voids in Mineral Aggregate (VMA) Criteria**	
Nominal Maximum Aggregate Size (mm)	**Minimum VMA, Percent**
9.5 (3/8”)	15
12.5 (1/2”)	14
19.0 (3/4”)	13
25.0 (1”)	12
37.5 (1-1/2”)	11

C. Furnished Mix Tolerances: Conform to asphalt concrete mix formula within the following, plus or minus:

1. Aggregate Passing 4.76 millimeter (No. 4) and Larger Sieves: 5 percent.
2. Aggregate Passing the 2.38 millimeter (No. 8) to 150 μm (100) Sieves: 4 percent.
3. Aggregate Passing the 75 μm (No. 200) Sieve: 2 percent.
4. Bitumen Content: 0.3 percent of volume or batch weight of aggregate.
5. Temperature Leaving Mixer: 11 degrees C (20 degrees F).
6. Temperature in Paving Machine Hopper: 11 degrees C (20 degrees F).

1.04 SUBMITTALS

A. Informational Submittals:

1. Asphalt Concrete Mix Formula:
    a. Submit minimum of 15days prior to start of production.
    b. Submittal to include the following information:
        1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
        2) Bulk specific gravity for each aggregate constituent.
        3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
        4) Percent of asphalt lost due to absorption by aggregate.
        5) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
        6) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.

7) Optimum mixing temperature.
8) Optimum compaction temperature.
9) Temperature-viscosity curve of asphalt cement to be used.
10) Brand name of any additive to be used and percentage added to mixture.

2. Test Report for Asphalt Cement:
   a. Submit minimum 10 days prior to start of production.
   b. Show appropriate test method(s) for each material and the test results.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, for the following materials:
   a. Aggregate: Gradation, source test results as defined in Sections 804 and 805 of the Standard Specifications.
   b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
   c. Prime Coat: Type and grade of asphalt.
   d. Tack Coat: Type and grade of asphalt.
   e. Additives.
   f. Mix: Conforms to job-mix formula.
4. Statement of qualification for independent testing laboratory.
5. Test Results:
   a. Mix design.
   b. Asphalt concrete core.
   c. Gradation and asphalt content of uncompacted mix.
   d. Field density.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

B. Compaction Control Strip:

1. General:
   a. Construct to approximately 400 square meters in area and at location that will become a portion of completed paved area.
   b. Thickness: Typical of thickness to be paved on Project.
2. Rollers Used for Compaction:
   a. Steel Wheel Rollers: Minimum static weight 9 Mg (10 tons).
   b. Pneumatic Rollers: Capable of exerting pressure of 550 Kpa (80 psi) on bituminous surface.

c. Vibratory Rollers: Static weight minimum 5.5 Mg (6 tons), capable of applying a 9-Mg (10-ton) impact force equipped with amplitude and frequency control specifically designed for compaction of bituminous mixtures.

3. Compaction:
   a. Compact bituminous mat, using a standard rolling pattern that covers entire control strip. Owner may require that Contractor perform a final density test.
   b. Continue rolling until no further compaction can be obtained as determined by field density testing.
   c. Temperature and condition of bituminous mat shall be considered workable when further compaction can no longer be obtained.
4. Target Density Determination:
   a. Select test point near center of normal roller pass, but no closer than 600 millimeters (2 feet) from edge of mat and 15 meters (50 feet) from either end of control strip. Mat thickness at this point shall be at least depth of finished pavement.
   b. Point at which no further densification can be obtained.
5. Establish new target density if change is made in mix design, nominal depth of mat being placed, aggregate source, or material properties.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 10 degrees C (50 degrees F) or air temperature is lower than 4 degrees C (40 degrees F). Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.

B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

PART 2 PRODUCTS

2.01 MATERIALS

A. Prime Coat: Cut-back asphalt, conform to Section 406 of the Standard Specifications.

B. Tack Coat: Emulsified asphalt, conform to Section 406 of the Standard Specifications.

C. Sand (Blotter Material): Clean, dry, with 100 percent passing 4.75-millimeter (No. 4) sieve, and a maximum of 10 percent passing 75 (m (No. 200) sieve.

2.02 ASPHALT CONCRETE MIX

A. General:

1. Mix formula shall not be modified except with written approval of Owner.
2. Source Changes:
   a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
   b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Owner to confirm that properties are in compliance with design criteria.
   c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

B. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.

C. Aggregate:

1. Coarse: Per Section 805 of the Standard Specifications.
2. Fine: Per Section 804 of the Standard Specifications
3. Natural Sand: May be used to a maximum of 15 percent by weight of total aggregate.

D. Asphalt Cement: as specified in Section 801 of the Standard Specifications.

PART 3 EXECUTION

3.01 GENERAL

A. Traffic Control:

1. In accordance with Section 01 50 00, Temporary Facilities and Controls.
2. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

B. Driveways: Repave driveways from which pavement was removed. Leave driveways in as good or better condition than before start of construction.

3.02 LINE AND GRADE

A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.

B. Shoulders: Construct to line, grade, and cross-section shown.

3.03 PREPARATION

A. Prepare subgrade as specified in Section 403 of the Standard Specifications.

B. Existing Roadway:

1. Modify profile by grinding, milling, or overlay methods as approved, to provide meet lines and surfaces and to produce smooth riding connection to existing facility.
2. Remove existing material to a minimum depth of 25 millimeters (1 inch).
3. Paint edges of meet line with tack coat prior to placing new pavement.

C. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.

3.04 PAVEMENT APPLICATION

A. General: Place asphalt concrete mixture on approved, prepared base in conformance with Section 403 of the Standard Specifications.

B. Prime Coat:

1. Heat cut-back asphalt, as specified in Section 406 of the Standard Specifications, prior to application.
2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
3. Do not apply when moisture content of upper 75 millimeters (3 inches) of base exceeds optimum moisture content of base, or if free moisture is present.
4. Application Rate: Minimum 70 (0.68) to maximum 2.28 liters per square meter of surface area (0.15 to 0.50 gallons per square yard).
5. Remove or redistribute excess material.
6. Allow a minimum of 5 full days for curing of primed surface before placing asphalt concrete.

C. Tack Coat:

1. Prepare material, as specified in Section 406 of the Standard Specifications, prior to application.
2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.

3. Do not apply more tack coat than necessary for the day's paving operation.
4. Touch up missed or lightly coated surfaces and remove excess material.
5. Application Rate:
    a. Minimum 0.25 liter to maximum 0.70 liter of asphalt (residual if diluted emulsified asphalt) per square meter (0.05 to 0.15 gallon per square yard) of surface area.
    b. Apply at rate, within range specified, sufficient to assure good bonding, but not so heavy that surplus asphalt flushes into asphalt concrete being placed.

D. Pavement Mix:

1. Prior to Paving:
    a. Sweep primed surface free of dirt, dust, or other foreign matter.
    b. Patch holes in primed surface with asphalt concrete pavement mix.
    c. Blot excess prime material with sand.
2. Place asphalt concrete pavement mix in one single lift.
3. Compacted Lift Thickness:
    a. Minimum: Twice maximum aggregate size, but in no case less than 25 millimeters (1 inch).
    b. Maximum: 100 millimeters (4 inches).
4. Total Compacted Thickness: As shown on Drawings
5. Apply such that meet lines are straight and edges are vertical.
6. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
7. Joints:
    a. Offset edge of each layer a minimum of 150 millimeters (6 inches) so joints are not directly over those in underlying layer.
    b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
    c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
8. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
9. After placement of pavement, seal meet line by painting a minimum of 150 millimeters (6 inches) on each side of joint with cut-back or emulsified asphalt. Cover immediately with sand.

E. Compaction:

1. Uniformly compact each course to target density arrived at in compaction control strip.

2. Uniformly compact each course until there is no further evidence of consolidation and roller marks are eliminated. When placement rate exceeds 90 mg (100 tons) per hour, operate minimum of two rollers for compaction.
3. Roll until roller marks are eliminated and minimum percent compaction as stated in the Standard Specifications is obtained.
4. Joint Compaction:
   a. Place top or wearing layer as continuously as possible.
   b. Pass roller over unprotected end of freshly laid mixture only when placing of mix is discontinued long enough to permit mixture to become chilled.
   c. Cut back previously compacted mixture when Work is resumed to produce slightly beveled edge for full thickness of layer.
   d. Cut away waste material and lay new mix against fresh cut.

F. Tolerances:

1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
2. Completed Surface or Wearing Layer Smoothness:
   a. Uniform texture, smooth, and uniform to crown and grade.
   b. Maximum Deviation: 3 millimeters (1/8 inch) from lower edge of a 3.6-meter (12-foot) straightedge, measured continuously parallel and at right angle to centerline.
   c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
3. Transverse Slope Maximum Deviation: 6 millimeters (1/4 inch) in 3.6 meters (12 feet) from rate of slope shown.
4. Finished Grade:
   a. Perform field differential level survey on maximum 15-meter (50-foot) meter grid and along grade breaks.
   b. Maximum Deviation: 6 millimeters (0.02 foot) from grade shown.

G. Seal Coat:

1. General: Apply seal coat of paving grade or emulsified asphalt to finished surface at longitudinal and transverse joints, joints at abutting pavements, areas where asphalt concrete was placed by hand, patched surfaces, and other areas as directed by Engineer.
2. Preparation:
   a. Surfaces that are to be sealed shall be maintained free of holes, dry, and clean of dust and loose material.
   b. Seal in dry weather and when temperature is above 2 degrees C (35 degrees F).

3. Application:
    a. Fill cracks over 1.5 millimeters (1/16 inch) in width with asphalt-sand slurry or approved crack sealer prior to sealing.
    b. When sealing patched surfaces and joints with existing pavements, extend minimum 150 millimeters (6 inches) beyond edges of patches.

3.05 PAVEMENT OVERLAY

A. Preparation:

1. Remove fatty asphalt, grease drippings, dust, and other deleterious matter.
2. Surface Depressions: Fill with asphalt concrete mix, and thoroughly compact.
3. Damaged Areas: Remove broken or deteriorated asphalt concrete and patch as specified in Article Patching.
4. Portland Cement Concrete Joints: Remove joint filler to minimum 12 millimeters (1/2 inch) below surface.

B. Application:

1. Tack Coat: As specified in this Section.
2. Place and compact asphalt concrete as specified in Article Pavement Application.
3. Place first layer to include widening of pavement and leveling of irregularities in surface of existing pavement.
4. When leveling irregular surfaces and raising low areas, the actual compacted thickness of any one lift shall not exceed 50 millimeters (2 inches).
5. Actual compacted thickness of intermittent areas of 100 square meters (120 square yards) or less may exceed 50 millimeters (2 inches), but not 100 millimeters (4 inches).
6. Final wearing layer shall be of uniform thickness, and meet grade and cross-section as shown.

3.06 PATCHING

A. Preparation:

1. Remove damaged, broken, or unsound asphalt concrete adjacent to patches. Trim to straight lines exposing smooth, sound, vertical edges.

B. Application:

1. Patch Thickness: 75 millimeters (3 inches) or thickness of adjacent asphalt concrete, whichever is greater.
2. Place asphalt concrete mix across full width of patch in layers of equal thickness.
3. Spread and grade asphalt concrete with hand tools or mechanical spreader, depending on size of area to be patched.

C. Compaction:

1. Roll patches with power rollers capable of providing compression of 350 to 525 Newtons per linear centimeter (200 to 300 pounds per linear inch). Use hand tampers where rolling is impractical.
2. Begin rolling top course at edges of patches, lapping adjacent asphalt surface at least 1/2 the roller width. Progress toward center of patch overlapping each preceding track by at least 1/2 width of roller.
3. Make sufficient passes over entire area to remove roller marks and to produce desired finished surface.

D. Tolerances:

1. Finished surface shall be flush with and match grade, slope, and crown of adjacent surface.
2. Tolerance: Surface smoothness shall not deviate more than plus 6 millimeters (1/4 inch) or minus 0 millimeter when straightedge is laid across patched area between edges of new pavement and surface of old surfacing.

3.07 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests.

B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T230 and AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:

1. Quality Control Tests:
   a. Asphalt Content, Aggregate Gradation: Once per every 400 mg (500 tons) of mix or once every 4 hours, whichever is greater.
   b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 900 mg (1,000 tons) or once every 8 hours, whichever is greater.
2. Density Tests: Once every 450 mg (500 tons) of mix or once every 4 hours, whichever is greater.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO).
    a. M6, Standard Specification for Fine Aggregate for Portland Cement Concrete.
    b. M80, Standard Specification for Coarse Aggregate for Portland Cement Concrete.
    c. M153, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
    d. M157, Standard Specification for Ready-Mixed Concrete.
    e. M213, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
    f. M227/M227M, Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties.
2. American Concrete Institute (ACI):
    a. 305R, Hot Weather Concreting.
    b. 306R, Cold Weather Concreting.
    c. 308, Standard Practice for Curing Concrete.
    d. 318/318R, Building Code Requirements for Structural Concrete and Commentary.
    e. 325.9R, Guide for Construction of Concrete Pavements and Concrete Bases.
3. ASTM International (ASTM):
    a. A615/A615M, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
    b. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
    c. C33, Specification for Concrete Aggregates.
    d. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
    e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
    f. C78, Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
    g. C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
    h. C94/C94M, Standard Specification for Ready-Mixed Concrete.

i. C143/C143M, Standard Test Method for Slump of Hydraulic Cement Concrete.
j. C150, Specification for Portland Cement.
k. C172, Standard Practice for Sampling Freshly Mixed Concrete.
l. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
m. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
n. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
o. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
p. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
q. C803/C803M, Test Method for Penetration Resistance of Hardened Concrete.
r. C1330, Specification for Cylindrical Seal Backing for Use With Cold Liquid Applied Sealants.
s. C805, Test Method for Rebound Number of Hardened Concrete.
t. D920, Standard Specification for Elastomeric Joint Seals.
u. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
v. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
w. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
x. D2628, Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete.
y. D2828, Specification for Non-Bituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type.
z. D3406, Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements.
aa. D3569, Specification for Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant Type for Portland Cement Concrete Pavements.
bb. D3581, Specification for Joint Sealant, Hot-Applied, Jet-Fuel-Resistant-Type, for Portland Cement and Tar-Concrete Pavements.
cc. D5249, Specification for Backer Material for Use With Cold- and Hot-Applied Joint Sealants in Portland Cement Concrete and Asphalt Joints.
dd. D5893, Specification for Cold-Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.

ee. E329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
4. National Ready Mixed Concrete Association (NRMCA).

1.02 DEFINITIONS

A. Standard Specification: Standard Specifications for Road and Bridge Construction – Kentucky Transportation Cabinet

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: Admixtures.
2. Design Data:
    a. Concrete mix design signed by concrete mix designer.
    b. Minimum Information:
        1) Name of ready-mix plant.
        2) Project.
        3) Engineer.
        4) Contractor.
        5) Mix design number.
        6) Specified concrete strength.
        7) Water-cement-fly ash ratio.
        8) Maximum aggregate size.
        9) Cement content.
        10) Fly ash content.
        11) Water content.
        12) Type, name, and amount of admixtures.
        13) Unit weight.
        14) Slump.
        15) Ingredient proportions corrected for average moisture content for particular times of year.
3. Jointing Drawings: Identify location and spacing of each type of joint.
4. Gradation for coarse and fine aggregates, and combined gradation. List percent passing each sieve size.
5. Detailed plan for cold weather placements, including curing and protection.
6. Detailed plans for hot weather placements, including curing and protection.

B. Informational Submittals:

1. Manufacturers' Certificate of Compliance:
    a. Portland cement.
    b. Admixtures.
    c. Fly ash.
    d. Aggregates.

2. Statements of Qualifications:
   a. Mix designer.
   b. Batch plant.
   c. Testing laboratory.
3. Test Reports:
   a. Admixtures: Chemical ingredients and percentage of chloride in each admixture and fly ash.
   b. Fly Ash: Source test analysis and amount used in accordance with ASTM C94/C94M, Section 16.
   c. Mix Design: For each trial, signed by qualified mix designer.
   d. Laboratory Mixes: Cylinder test results.
4. Concrete Delivery Tickets:
   a. For each batch of concrete before unloading at Site.
   b. Minimum Delivery Ticket Information:
      1) Name of ready-mix plant.
      2) Serial number of ticket.
      3) Date and truck number.
      4) Name of Contractor.
      5) Job name and location.
      6) Mix design number.
      7) Amount of concrete (cubic yards).
      8) Type and amount of admixtures.
      9) Amount of water added at batch plant.
      10) Time of loading, arriving at Site, and unloading.
      11) Volume of water added by receiver of concrete and their initials.
   c. Record of drum revolution counter, type, and brand.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Mix Designer: Licensed professional engineer registered in the state of Project or a certified concrete mix designer approved by Kentucky Department of Transportation.
2. Testing or Inspection Agency: In conformance with ASTM E329.
3. Batch Plant: Currently certified by the National Ready Mixed Concrete Association.

B. Hot Weather Concreting: Conform to ACI 305R.

C. Cold Weather Concreting: Conform to ACI 306R.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Transporting of ready-mix concrete shall be in accordance with ASTM C94/C94M.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Cement:

1. Furnish cement for Project from one source.
2. Provide as required in Section 03 30 00, Cast-in-Place Concrete.
3. Portland cement shall be Type II, meeting the requirements of the Standard Specification.
4. In accordance with ASTM C150.

B. Aggregates:

1. General:
   a. Aggregate for portland cement concrete mixture shall be 2-inch maximum size stone meeting requirements of Standard Specifications.
   b. Material: Natural aggregates, free from deleterious coatings.
   c. Aggregates shall not be potentially reactive as defined in ASTM C33.
   d. Aggregates not in compliance with soundness and durability requirements of ASTM C33 may be used with prior approval of Engineer; provided it can be shown by special testing or record of past performance that these aggregates produce concrete of adequate strength and durability. Aggregate soundness testing for fine and coarse aggregates shall be in accordance with ASTM C33 and ASTM C88.
2. Fine Aggregates:
   a. Grading meeting requirements of the Standard Specifications.
   b. Must be graded coarse to fine within the following limits.

General Requirements	
Sieve Size Passing	**Percentages by Weight**
3/8"	100
No. 4	90-100
No. 8	55-85
No. 16	45-75
No. 30	25-55
No. 50	5-30
No. 100	0-8

   c. Sand: Equivalent of not less than 68.
   d. Materials finer than 200 sieve shall not exceed 4 percent.

3. Coarse Aggregate:
   a. Grading meeting requirements of the Standard Specifications.
   b. Materials finer than 200 sieve shall not exceed 0.5 percent.
   c. Size: 1-1/2-inch to No. 4.

Grading Requirements		
Sieve Size Passing	**Separated Sizes 1-1/2 Inch to 3/4 Inch**	**Percentages (by Weight) 3/4 Inch to No. 4**
2"	100	
1-1/2"	90-100	
1"	30-65	100
3/4"	0-15	90-100
3/8"		20-50
No. 4		0-10

C. Physical Properties:

1. Meet requirements of AASHTO M80 for Class BCD.
2. In accordance with the Standard Specifications.

D. Water: ASTM C94/C94M.

E. Admixtures:

1. Add admixtures to mix at batch plant.
2. Air Entraining: ASTM C260.
3. Water Reducing:
   a. ASTM C494/C494M Type A, normal, containing no chlorides and compatible with air-entraining admixtures.
   b. Type E, accelerating water reducing type, may be used with prior approval by Engineer.
   c. Do not use calcium chloride, salt, or antifreeze agents.

2.02 ANCILLARY MATERIALS

A. Tie Bars: Grade 40 deformed steel bars conforming to Section 03 21 00, Reinforcing Steel.

B. Dowels: Conform to requirements of AASHTO M227/M227M, Grade 70.

C. Joint Filler:

1. Preformed expansion joint filler: conforming to AASHTO M153 or AASHTO M213 or as specified in Section 03 15 00, Concrete Joints and Accessories.
2. Fillers furnished under AASHTO M213 shall be tested in accordance with ASTM D1751.

D. Joint Sealant:

1. Preformed elastomeric joint seal conforming to AASHTO M220.
2. Hot-poured elastomeric joint seal conforming to AASHTO M282.
3. Cold-applied single component joint sealant conforming to ASTM D5893.
4. Elastomeric joint sealant conforming to ASTM C920.

E. Backer Rod:

1. Backer material conforming to ASTM D5249.
2. Cylindrical sealant backing conforming to ASTM C1330.

F. Curing Compound: ASTM C309, Type 1Class A, Class B, suitable for spray application.

G. Curing Membranes:

1. White polyethylene sheeting.
2. Waterproof paper.
3. Cotton or jute mats.

H. Evaporation Retardant: Confilm as manufactured by Master Builders Company.

2.03 EQUIPMENT

A. Ready-Mix Concrete Batch Plants: Certified by NRMCA.

B. Batch Plants:

1. Conform to requirements of the Standard Specifications.
2. Bins shall have adequate separate compartments for fine aggregate, each separate size of coarse aggregate and cement. Bins and compartments shall be tight and ample to prevent spilling from one bin to another. Separate compartments, including weighting hoppers, shall discharge freely and efficiently.

3. Scales for weighing aggregates and cement may be either beam type or springless dial type. They shall be accurate within 0.5 percent under operating conditions throughout the range of use and, tested and adjusted as often as Engineer may deem necessary to assure their continued accuracy.
4. Equipment for dispensing water and admixtures shall provide a separate feed, accurate quantity measurement, and shall inject water and admixture at a time in mixing process to ensure thorough and complete mixing throughout batch of portland cement concrete.
5. Automatically controlled batchers shall have automatically interlocked mechanisms providing the following:
    a. Positive weighing and discharge of cement and of each separate size of aggregate.
    b. Interlocking between weighing hoppers to prevent part of batch from being discharged until each separate hopper has been filled with correct proportion.
    c. Simultaneous discharge of hoppers.
    d. Lockable compartment containing time setting controls.
6. Equip mixers with a timing device that will not permit batch to be discharged until specified mixing time has elapsed. The means of storing, measuring and introducing water into mixer shall provide positive control and accurate measurement.

C. Ready-Mix Concrete Trucks:

1. As specified in the Standard Specifications.
2. Agitator mixer type.
3. Equipped with operable electrically actuated drum revolution counters.
4. Use of nonagitator equipment will not be permitted.
5. Each mixer shall carry a clearly visible manufacturer's plate showing capacity of mixer and other pertinent operating rates and limits.
6. Provision shall be made at mixer for controlled addition of air-entraining admixtures or other special components of mix.
7. Mixing Speed: 70 to 100 revolutions at a mixing speed recommended by truck mixer manufacturer.

D. Hauling Equipment:

1. As specified in the Standard Specifications.
2. Hauling equipment shall conform to AASHTO M157, Paragraph 11.6 and Paragraph 12.
3. Upon delivery of each batch of concrete to Site, a trip ticket shall be submitted to Engineer.

E. Paving Equipment:

1. As specified the Standard Specifications.
2. Slipform Paver:

a. Place portland cement concrete with two separate machines, one a spreader and one a slipform paver. Machines, when operating in tandem shall spread, consolidate, screed, and float finish freshly placed portland cement concrete in one pass with a minimum of hand finishing. Each machine shall be fully self-propelled and equipped with electronic controls to control line and grade from both sides.
b. Spreader shall be able to deliver mix without segregation or displacing reinforcing steel.
c. Able to vibrate portland cement concrete for full width and depth and be equipped with vibrating tubes or arms to work in portland cement concrete. Sliding forms shall be held together rigidly to prevent them from spreading. Form shall be long enough so slumping of portland cement concrete will not exceed 1/4 inch.
d. Supports of paver and other equipment which ride on previously placed pavement shall be equipped to prevent marring, edge breaking, or chipping of previously placed pavement.

3. Bridge Deck Finisher/Paver: A bridge or similar finishing/paving machine utilizing previously constructed and cured curb and gutter as side forms and support for machine rails may be used with prior approval of Engineer.

F. Concrete Saws:

1. Provide power driven concrete saws for sawing joints or finishing concrete, adequate in number of units and power to complete sawing at required rate.
2. Saws and related equipment shall be of proven adequacy and design to perform efficiently and shall be subject to immediate replacement, if specified results are not obtained.
3. Standby saw shall be available at Site.

G. Smoothness Testing Equipment: Supply two 12-foot straightedges for determining smoothness.

2.04 CONCRETE MIX DESIGN

A. As specified in Section 03 30 00, Cast-in-Place Concrete, with a minimum flexural strength of 650 psi.

B. Compressive strength of 4,000 psi minimum and flexural strength of 650 psi minimum, both at 28 days.

1. If the 650 psi flexural strength specification requires a compressive strength in excess of 4,000 psi, the higher compressive value shall be used as a standard minimum for compressive strength cylinder tests taken during construction.

2. The relationship between compressive strength f_c and modulus of rupture f_r shall be:

$$f_r = k\sqrt{f_c}$$

with k derived from the tests results.

C. Concrete target strengths shall be in accordance with ACI 318/318R.

D. Maximum water-cement ratio or water-cement plus pozzolan ratio, if applicable, shall not exceed 0.48.

E. Maximum Aggregate Size: 3/4 inch(es) minus.

F. Allowable Slump: 3 inches, plus or minus 1 inch.

G. Allowable Air Entrainment: 5 percent, plus or minus 1 percent by volume.

H. Concrete shall contain water reducer. Amount of admixture added to concrete shall be in accordance with manufacturer's written instructions.

I. Use of set-retarding admixtures shall be subject to prior approval by Engineer.

J. Do not use frozen materials or materials containing ice or snow.

K. Concrete temperature as delivered to site ready for placement shall be above 50 degrees F and below 90 degrees F.

L. If Contractor proposes to use a current mix design that meets these Specifications, has been used on previous project, and less than 1 year has elapsed since it was last used; Contractor shall submit documentation of production of concrete produced from that mix design to Engineer for review. If review verifies concrete produced meets these Specifications and strength requirements, and establishes a correlation between compressive strength and flexural strength, no trial batches for proposed mix design will be required.

PART 3 EXECUTION

3.01 WEATHER LIMITATIONS

A. Concrete shall not be placed:

1. Until the air temperature in the shade is 35 degrees F and rising and is forecast to remain above 35 degrees F.
2. On frozen ground.
3. During periods of rain or snow.

B. Concrete placement shall not continue when air temperature drops below 40 degrees F.

C. Protect concrete pavement from inclement weather for 7 days after it has been placed, when rain is imminent, and when air temperature drops or is forecast to drop below 35 degrees F.

3.02 PREPARATION

A. Prepare base as specified in the Standard Specifications.

B. Dampen base thoroughly prior to concrete placement; standing water will not be permitted.

C. Formwork shall be complete prior to placement of concrete. Area in which concrete is to be placed, shall be smooth and free of ruts, projections, debris, spilled concrete, mud, sloughed soil, standing water, organic and other objectionable materials.

D. Construction Joints: Inspect prior to placement of concrete.

E. Prior to placing paving equipment in position, full width and length of the area on which the tracks of the paving equipment is to operate shall be brought to density and surface tolerances required.

F. Protect existing exposed surfaces such as grates, catch basins, air valves, manholes, and cleanout lids from splattered and spilled concrete during concrete placement by use of durable waterproof paper.

G. Furnish operable backup vibrator on Site prior to concrete placement.

3.03 SLIP FORM PAVING

A. Deliver from hauling vehicles to paving machine hopper.

B. Contractor's equipment hauling portland cement concrete or reinforcement will not be permitted on subgrade, but will be allowed on base, with turns or other maneuvering kept to a minimum. Damage to subgrade or base shall be corrected to satisfaction of Engineer.

C. Place in final position uniformly in one layer, so a minimum of finishing will be necessary to provide a dense, homogenous pavement conforming to true grade and cross section.

1. Spreader shall receive portland cement concrete mixture in its hopper and uniformly spread and strike it off at proper thickness for full width of area being paved.
2. Paver shall vibrate, consolidate, and finish slab to proper grade and cross section.

D. Paver:

1. Operated with as continuous forward movement as possible.

2. Coordinate mixing, delivering, and spreading portland cement concrete to provide uniform progress.
3. Stopping and starting paver shall be held to a minimum. If, for any reason, it is necessary to stop forward motion of paver, vibratory and tamping elements shall also be stopped immediately.
4. No external force shall be applied to paver, except with approval of Engineer.

E. While placing portland cement concrete, provision shall be made for constructing joints, placing dowels, tie bars, and other devices as called for by Drawings and as provided in Article Joints.

F. Portland cement concrete shall be rejected if it:

1. Is not in place within 1 hour after being mixed.
2. Has begun to take an initial set prior to placement.
3. Has been retempered with water.

G. If necessary, supplemental hand spreading and distributing shall be with shovels. Rakes will not be permitted.

H. Portland cement concrete shall not be fouled with foreign matter.

I. Use vibrators to consolidate portland cement concrete pavement at least 6 feet each side of construction joints and expansion joints.

3.04 STATIONARY SIDE FORM CONSTRUCTION

A. Where width of pavement is narrow, tapering, or of irregular pattern not lending itself to being constructed by prescribed machine methods, Contractor shall be permitted to place concrete as specified in Section 03 30 00, Cast-in-Place Concrete.

B. Defects:

1. Fill areas of minor honeycomb or other minor defect in composition of portland cement concrete along exposed edges of portland cement concrete with a stiff mortar of cement and fine aggregate. Apply to moistened portland cement concrete to satisfaction of Engineer.
2. Area showing serious defects in composition of concrete shall be removed and replaced with pavement of specified quality for full width of strip between longitudinal joints or edges and for a length not less than between the nearest transverse joints.

3.05 JOINTS

A. General:

1. Referred to as contraction or construction, either of which may be transverse or longitudinal, as called for by Drawings or as approved by Engineer.
2. Joints, backer material, joint filler and joint sealants shall extend to pavement edges or to each other, as the case may be, and shall be constructed perpendicular to surface of pavement.
3. Joints shall not vary from specified or indicated line by more than 1/4 inch.
4. Contractor shall submit jointing plan and details to Engineer for approval. Take into consideration placement of joints in curb and gutter, at catch basins, and position of manholes and other large structures, as well as other limitations herein mentioned.
5. Place manhole or similar large structure in line of joint, or if impractical, isolate structure from pavement with premolded joint filler, 1/2-inch wide, conforming to AASHTO M213 and ASTM D1751.

B. Contraction Joints:

1. Sawed Type with Poured Filler:
    a. Sawing shall be to a depth as shown on Drawings with a maximum width of 1/4 inch and a minimum width of 1/8 inch, in straight lines as shown or as approved by Engineer.
    b. Perform saw cuts as soon as portland cement concrete has set enough to permit sawing without tearing or raveling, before uncontrolled cracking results, and within 24 hours of placing portland cement concrete.
    c. Saws may be single or tandem, as Contractor may elect, and shall be controlled by guides to true line.
    d. Clean joints thoroughly of foreign matter before pouring approved rubber asphalt filler.
    e. Tops of joint filler shall be true to pavement cross section within 1/8 inch and shall be protected from damage by portland cement concrete operations.
    f. Areas containing uncontrolled cracks shall be removed and replaced.
    g. Restore curing agents broken or damaged by sawing operations.
2. Space longitudinal joints as shown on Drawings at the interface between lanes, normally at intervals between 12 feet to 16 feet.
3. Transverse joints shall be as shown on Drawings or as approved by Engineer, with intervals of 12 feet to 16 feet.

C. Construction Joints:

1. Construct when there is an interruption of longer 45 minutes in portland cement concrete placing operations or where specified.
2. Place parallel with intended contraction joint.
3. Tool both free edges of joints with 1/8 inch radius rounder to remove laitance and mortar resulting from finishing operations and to provide clean rounded edge. Tooling shall not form ridges on surface of concrete.
4. New portland cement concrete placed contiguous to joint shall conform to proportions and consistency of previously placed concrete.
5. Transverse Construction Joint:
    a. As shown on Drawings.
    b. If sufficient portland cement concrete has not been mixed at the time of interruption to place a construction joint at least 3 feet from a planned contraction joint, remove excess portland cement concrete back to a position to satisfactorily meet these criteria and to satisfaction of Engineer.
    c. Fill joint which has opened to a width of 1/8 inch or greater during construction or maintenance periods with poured filler.
    d. Do not construct within 3 feet of a transverse contraction joint.
6. Longitudinal Construction Joint:
    a. Tied type using No. 5 by 36-inch deformed tie bars at 12-inch centers.
    b. Tie Bars:
        1) Not required at construction joint between portland cement concrete pavement and gutter, except where shown on Drawings and mentioned above.
        2) Placement:
            a) Plastic Portland Cement Concrete: Insert before vibrating and finishing portland cement concrete; or
            b) Hardened Concrete:
                (1) Drill hole, insert, and grout tie bars into place.
                (2) Drill holes large and deep enough to allow tie bars to be inserted with grout.
                (3) Perform any time after portland cement concrete has attained enough strength to resist any damage caused by drilling.
                (4) Tie bars shall be grouted a maximum of 3 hours prior to placement of adjacent portland cement concrete.
        3) Replace loose tie bars by drilling and grouting as described.

D. Scored Joints:

1. Configuration: 1/4-inch wide by 1/4-inch deep at locations indicated on Drawings formed by tooling of concrete while it is still fresh.
2. Do not fill or seal.

3. Layout of joints shall be straight and true and shall not vary from indicated line by more than 1/4 inch.

3.06 SURFACE FINISHING

A. Use temporary screeds. Wet screeding and jitterbugging shall not be permitted.

B. Pavement shall have surface tolerance of 1/4 inch in 10 feet in accordance with ACI 325.9R.

C. Salting, spreading of cement or cement and sand mixture to speed up hardening shall not be permitted.

D. Exposed pavement edges shall be edged to a 1/2-inch radius and construction joints shall be edged to 1/8-inch radius after finishing. Edging shall not form ridges on pavement surface.

E. Pavement shall be treated and protected by use of evaporation retardant applied in accordance with manufacturer's written instructions. Flat surfaces shall be treated immediately after screeding and floating or if time period greater than 15 minutes occurs between finishing operations.

F. Pavement shall be screeded, floated, and given a broomed or burlap drag skid-resistant surface.

1. Broomed surface with hand broom or mechanical broom device to produce 1/16-inch to 1/8-inch deep striations oriented pendicular to the direction of travel.
2. Burlap Drag Finish: Trail moistened coarse burlap from a device that allows control of the time and rate of texturing to provide a uniform finish with 1/16-inch- to 1/8-inch-deep striations.

3.07 CURING OF PORTLAND CEMENT CONCRETE

A. Immediately after the final floating, surface finishing, and edging has been completed, and while portland cement concrete surface is still moist, cover and cure entire exposed surface for at least 72 hours in accordance with one of the following provisions:

1. Liquid Membrane-Forming Compounds: Apply compound uniformly to portland cement concrete by pressure spray methods at a rate which will form an impervious membrane, but at least at a rate of 1 gallon per 150 square feet.
2. Other Membranes:
   a. Apply to damp portland cement concrete as soon as it can be placed without marring surface.

3.10 PROTECTION OF CONCRETE

A. Do not operate construction equipment or allow traffic on newly placed portland cement concrete until the following requirements are met:

   1. Joints have been filled as per Article Joints.
   2. Concrete has attained a compressive strength of at least 4,000 pounds per square inch.

B. Protect new concrete from construction operations, mechanical disturbances, water flow, and soiling until open for traffic.

C. Erect and maintain suitable barriers to protect concrete from traffic or other detrimental trespass until pavement is opened to traffic.

D. Maintain watchmen after normal working hours for at least a 24-hour period to ensure barriers are not removed or destroyed, and that trespass and vandalism upon pavement does not occur.

E. Wherever it is necessary that traffic, including Contractor's vehicles and equipment, be carried from one side of pavement to the other, construct suitable bridges over pavement, and maintain them in good condition as long as they may be required. Leaving gaps in pavement to facilitate movement of traffic will not be allowed, unless prior written permission is obtained from Engineer.

F. Protect new concrete from dirt, asphalt, and other deleterious substances that may be tracked onto new pavement from construction activities.

G. Pavement damaged by traffic or damaged from any other cause, prior to its official acceptance, shall be repaired or replaced to the satisfaction of Engineer.

END OF SECTION

SECTION 32 16 00
CURBS AND GUTTERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): T 99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in.) Drop.
2. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
3. ASTM International (ASTM):
   a. C94, Standard Specification for Ready-Mixed Concrete.
   b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   c. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
4. Standard Specification: State of Kentucky.

1.02 SUBMITTALS

A. Action Submittals:

1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.

B. Informational Submittals:

1. Curing Compound: Manufacturer's Certificate of Compliance and application instructions.
2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to the State of Kentucky Standard Specifications for Highway Construction.

PART 2 PRODUCTS

2.01 MATERIALS

A. Conform to the requirements of the referenced Standard Specification.

2.02 EXPANSION JOINT FILLER

A. Preformed asphalt-impregnated, expansion joint material meeting ASTM D994, 1/2-inch thick.

2.03 CONCRETE

A. Ready-mixed meeting ASTM C94, Option A, with compressive strength of 3,300 psi at 28 days. As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Maximum Aggregate Size: 1-1/2 inch.

C. Slump: 2 inches to 4 inches.

2.04 CURING COMPOUND

A. Liquid membrane forming, clear or translucent, suitable for spray application and meeting ASTM C309, Type 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Perform Work in accordance with the referenced Standard Specification.

3.02 FORMWORK

A. Lumber Materials:

1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed curb and sidewalk.
2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.

B. Metals: Steel in new undamaged condition.

C. Setting Forms:

1. Construct forms to shape, lines, grades, and dimensions.
2. Stake securely in place.

D. Bracing:

1. Brace forms to prevent change of shape or movement resulting from placement.
2. Construct short-radius curved forms to exact radius.

E. Tolerances:

1. Do not vary tops of forms from gradeline more than 1/8 inch when checked with 10-foot straightedge.
2. Do not vary alignment of straight sections more than 1/8 inch in 10 feet.

3.03 PLACING CONCRETE

A. Prior to placing concrete, remove water from excavation and debris and foreign material from forms.

B. Place concrete as soon as possible, and within 1-1/2 hours after adding cement to mix without segregation or loss of ingredients, and without splashing.

C. Place, process, finish, and cure concrete in accordance with applicable requirements of ACI 304, and this section. Wherever requirements differ, the more stringent shall govern.

D. To compact, vibrate until concrete becomes uniformly plastic.

3.04 CURB CONSTRUCTION

A. Construct ramps at pedestrian crossings.

B. Expansion Joints: Place at maximum 45-foot intervals and at the beginning and end of curved portions of curb and at connections to existing curbs. Install expansion joint filler at each joint.

C. Curb Facing: Do not allow horizontal joints within 7 inches from top of curb.

D. Contraction Joints:

1. Maximum 15-foot intervals in curb.
2. Provide open joint type by inserting thin, oiled steel sheet vertically in fresh concrete to force coarse aggregate away from joint.
3. Insert steel sheet to full depth of curb.
4. Remove steel sheet with sawing motion after initial set has occurred in concrete and prior to removing front curb form.
5. Finish top of curb with steel trowel and finish edges with steel edging tool.

E. Front Face:

1. Remove front form and finish exposed surfaces when concrete has set sufficiently to support its own weight.
2. Finish formed face by rubbing with burlap sack or similar device to produce uniformly textured surface, free of form marks, honeycomb, and other defects.
3. Remove and replace defective concrete.
4. Apply curing compound to exposed surfaces of curb upon completion of finishing.
5. Continue curing for minimum of 5 days.

F. Backfill curb with earth upon completion of curing period, but not before 7 days has elapsed since placing concrete.

1. Backfill shall be free from rocks 2 inches and larger and other foreign material.
2. Compact backfill firmly.

3.05 SIDEWALK CONSTRUCTION

A. Thickness:

1. 4 inches in walk areas.
2. 6 inches in driveway areas.

B. Connection to Existing Sidewalk:

1. Remove old concrete back to an existing contraction joint.
2. Clean the surface.
3. Apply a neat cement paste immediately prior to placing new sidewalk.

C. Expansion Joints: Place in adjacent curb, where sidewalk ends at curb, and around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.

D. Contraction Joints:

1. Provide transversely to walks at locations opposite contraction joints in curb.
2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
3. Construct straight and at right angles to surface of walk.

E. Finish:

1. Broom surface with fine-hair broom at right angles to length of walk and tool at edges, joints, and markings.
2. Mark walks transversely at 5-foot intervals with jointing tool; finish edges with rounded steel edging tool.
3. Apply curing compound to exposed surfaces upon completion of finishing.
4. Protect sidewalk from damage and allow to cure for at least 7 days.

END OF SECTION

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SECTION 32 17 23
PAVEMENT MARKINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M237, Standard Specification for Epoxy Resin Adhesives for Bonding Traffic Markers to Hardened Portland Cement and Asphalt Concrete.
   b. M247, Standard Specification for Glass Beads Used in Traffic Paint.
   c. M248, Standard Specification for Ready-Mixed White and Yellow Traffic Paints.
   d. M249, Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form).
2. ASTM International (ASTM): D4280, Standard Specification Extended Life Type, Nonplowable, Prismatic, Raised, Retroreflective Pavement Markers.
3. Federal Specifications (FS):
   a. A-A-2886A, Paint, Traffic, Solvent Based.
   b. TT-B-1325C, Beads (Glass Spheres); Retroreflective.

1.02 DEFINITIONS

A. Standard Specifications: Standard specifications for road and bridge construction, Kentucky Transportation Cabinet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Paint.
      2) Thermoplastic material.
      3) Reflective markers.
      4) Epoxies, resins, and primers to be used.
   b. Glass Beads: Proposed gradation.

B. Informational Submittals:

1. Description of proposed methods for removal of drips, overspray, improper markings, paint and thermoplastic material tracked by traffic, and existing markings.
2. Manufacturer's Certificate of Compliance for products specified in this section.
3. Equipment List: Proposed equipment to be used, including descriptive data.
4. Manufacturer's Instructions:
   a. Application of preformed tape.
   b. Application of portland cement concrete primer.
   c. Application of glass beads.
   d. Application of epoxy resin.
   e. Installation of reflective markers.

PART 2 PRODUCTS

2.01 GENERAL

A. All products shall be in accordance with the Standard Specifications.

2.02 PAINT

A. Color: White or yellow.

B. Traffic paint in accordance with Section 842 of the Standard Specifications.

C. Homogeneous, easily stirred to smooth consistency, with no hard settlement or other objectionable characteristics during storage period of 6 months.

PART 3 EXECUTION

3.01 GENERAL

A. Surface Preparation, Application, and Protection: In accordance with Section 842 of the Standard Specifications.

3.02 SURFACE PREPARATION

A. Cleaning:

1. Thoroughly clean surfaces to be marked before application of pavement marking material.

2. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water or a combination of these methods.
3. Completely remove rubber deposits, surface laitance, existing paint markings, and other coatings adhering to pavement with scrapers, wire brushes, sandblasting, approved chemicals, or mechanical abrasion.
4. Scrub areas of old pavement affected with oil or grease with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application.
5. Surfaces shall be completely free of dirt and ice, and dry of water at the time of application of materials specified herein.
6. Oil-Soaked Areas: After cleaning, seal with cut shellac to prevent bleeding through the new paint.
7. Reclean surfaces when the Work has been stopped due to rain.
8. Existing Pavement Markings:
   a. Remove existing pavement markings that may interfere or conflict with newly applied marking patterns, or that may result in a misleading or confusing traffic pattern.
   b. Do not apply thermoplastic markings over existing preformed or thermoplastic markings.
   c. Perform grinding, scraping, sandblasting or other operations so finished pavement surface is not damaged.

B. Pretreatment for Early Painting: Where painting is required prior to 30 days after paving rigid pavements, pretreat with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride.

C. New Concrete Pavement:

1. Allow a minimum cure time of 30 days before cleaning and marking.
2. Clean by either sandblasting or water blasting to the following results:
   a. No visible evidence of curing compound on peaks of textured concrete surface.
   b. No heavy puddled deposits of curing compound in valleys of textured concrete surface.
   c. Remaining curing compound is intact, with loose and flaking material completely removed.
   d. Peaks of textured pavement surface are rounded in profile and free of sharp edges and irregularities.
3. Allow a minimum drying time of 24 hours after water blasting before applying thermoplastic markings.

D. New Asphalt Pavement: Allow a minimum pavement cure time of 30 days before applying paint.

3.03 PAINT APPLICATION

A. General:

1. Thoroughly mix pigment and vehicle together prior to application, and keep thoroughly agitated during application.
2. Do not add thinner.
3. Apply only when air and pavement temperatures are above 40 degrees F and less than 95 degrees F. Maintain paint temperature within these same limits.
4. Apply only when surface is dry.
5. Do not apply when conditions are windy to the point of causing overspray or fuzzy line edges.
6. Provide guidelines and templates to control paint application.
7. Take special precautions in marking numbers, letters, and symbols.
8. Sharply outline edges of markings and apply without running or spattering.

B. Rate of Application:

1. On new pavement or new asphalt surface treatments, apply two coats of paint at a uniform rate of 210 square feet per gallon.

C. Drying:

1. Provide maximum drying time to prevent undue softening of bitumen and pickup, displacement, or discoloration by traffic.
2. If drying is abnormally slow, discontinue painting operations until cause is determined and corrected.

D. Protection:

1. Protect markings from traffic until paint is thoroughly dry.
2. Protect surfaces from disfiguration by paint spatters, splashes, spills, or drips.

E. Cleanup: Remove paint spatters, splashes, spills, or drips from the Work and staging areas including areas outside the immediate Work area where spills occur.

END OF SECTION

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
    a. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
    b. A313/A313M, Standard Specification for Stainless Steel Spring Wire.
    c. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
    d. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
    e. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
    f. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
    g. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
    h. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
    i. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
    j. C94/C94M, Standard Specification for Ready-Mixed Concrete.
    k. C150, Standard Specification for Portland Cement.
    l. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
    m. F552, Standard Terminology Relating to Chain Link Fencing.
    n. F567, Standard Practice for Installation of Chain-Link Fence.
    o. F626, Standard Specification for Fence Fittings.
    p. F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
    q. F900, Standard Specification for Industrial and Commercial Swing Gates.
    r. F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
    s. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.

t. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
u. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
v. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
w. F1379, Standard Terminology Relating to Barbed Tape.
x. F1911, Standard Practice for Installation of Barbed Tape.
y. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications.

2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: C2, National Electrical Safety Code.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.02 DEFINITIONS

A. Terms as defined in ASTM F552.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Include construction details, material descriptions, dimensions of individual components, and finishes for chain link fences and gates.
      1) Fence, gate posts, rails, and fittings.
      2) Chain link fabric.
      3) Gates and hardware.
2. Samples:
   a. Chain Link Fabric: Approximately 6 inches square.
   b. Posts, Rails, Braces, Wire, and Ties: Approximately 6 inches long.
   c. Fittings: 1 each.
3. Test Reports: Field test result for compliance of installation of chain link fence, gates, and gate operators.

B. Informational Submittals:

1. Manufacturer's recommended installation instructions.
2. Evidence of Supplier and installer qualifications.
3. Operation and Maintenance Data as specified in Section01 78 23, Operation and Maintenance Data.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.05 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing chain link fence and gates.

B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

PART 2 PRODUCTS

2.01 GENERAL

A. Match style, finish, and color of each fence component with that of other fence components.

2.02 CHAIN LINK FENCE FABRIC

A. PVC-coated or Polymer-coated galvanized fabric conforming to ASTM F668, Class 1 or Class 2a over metallic-coated steel wire.

1. Color: Dark Green – match existing.

B. Height: match existing.

C. Pattern: match existing.

D. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.

E. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

F. Wires of Twisted Selvages:

1. Twisted in a closed helix three full turns.
2. Cut at an angle to provide sharp barbs that extend minimum 1/4 inch beyond twist.

2.03 POSTS

A. General:

1. Strength and Stiffness Requirements: ASTM F1043, : heavy industrial fence, except as modified in this section.
2. Round Steel Pipe, Schedule 40: ASTM F1083.
3. Roll-Formed Steel Shapes: Roll-formed from ASTM A1011/A1011M, Grade 45, High-Strength Low-Alloy steel.
4. Lengths: Manufacturer's standard with allowance for minimum embedment below finished grade of 34 inches.
5. Protective Coatings:
   a. Zinc Coating: ASTM F1043, Type A external and internal coating.
6. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.

B. Line Posts: match existing size and style.

C. End, Corner, Angle, and Pull Posts: match existing size and style.

2.04 TOP AND BRACE RAILS

A. Match existing size and style.

B. Protective Coatings: As specified for posts.

C. Strength and Stiffness Requirements: ASTM F1043, top rail, heavy industrial fence.

2.05 FENCE FITTINGS

A. General: In conformance with ASTM F626, except as modified by this article.

B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension Bars:

1. One-piece.
2. Length not less than 2 inches shorter than full height of chain link fabric.
3. Provide one bar for each gate and end post, and two for each corner and pull post.

D. Truss Rod Assembly: 3/8-inch diameter, steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

E. Tie Wires, Clips, and Fasteners: According to ASTM F626.

2.06 TENSION WIRE

A. Zinc-coated steel marcelled tension wire conforming to ASTM A824.

2.07 BARBED WIRE

A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:

B. Aluminum-Coated Steel Barbed Wire: ASTM A121, Type I or II.

1. Line Wire: Two strands of No. 12-1/2 gauge.
2. Barbs:
   a. Number of Points: Two.
   b. Length: 3/8 inch minimum.
   c. Shape: Round.
   d. Diameter: No. 14 gauge.
   e. Spacing: 5 inches.

2.08 BARBED TAPE

A. Series 430 stainless steel hardened to Rockwell (30N) 35-40 minimum; 0.025-inch thick by 1-inch wide before fabrication, die stamped to produce clusters of four pointed needle-sharp barbs at 4 inches on center, minimum 1.2 inches long, offset in alternate directions 0.15 to 0.45 inch.

B. Permanently cold clench stainless steel strip to minimum 230 degrees F around core wire.

C. Core wire: 0.098-inch diameter, high-tensile-strength stainless steel complying with ASTM A313/A313M.

D. Stainless steel strip between barb clusters shall be 1/4-inch wide minimum after cold clenching to create a flange extending out from the wire, tapering off adjacent to the barb cluster to allow maximum barb penetration.

E. Fabrication: Continuous coils of barbed tape as defined in ASTM F1379 for the following characteristics:

1. Configuration: Double coil.
2. Style: Concertina pattern.

3. Coil Diameters: 24-inch inner coil and 30-inch outer coil, plus or minus 2 inches, when coil compressed.
4. Coil Loop Spacing: 12 inches.

F. Clips: Stainless steel, 0.065-inch thick by 0.375-inch wide; capable of withstanding a minimum pull load of 200 pounds for a minimum of 30 seconds without separation, or other damage.

G. Tie Wires: Stainless steel, 0.065-inch diameter.

2.09 CONCRETE

A. Materials: ASTM C387, packaged, dry, combined ingredients with Type I cement.

B. Mixing: In a clean metal container, mix package of dry materials by hand or machine. Following manufacturer's instructions, add clean water in sufficient quantity to produce a slump of 2 inches to 3 inches.

2.10 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1-inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Comply with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel.

PART 3 EXECUTION

3.01 GENERAL

A. Install chain link fences in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.

B. Provide necessary hardware for a complete fence and gate installation.

C. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.

D. Drainage Crossings: Where the chain-link fence must cross drainage ditches or swales, the main fence shall be carried across a ditch or swale with additional fence added below.

1. Frames and Bracing: The fence added below shall be fabricated with galvanized round steel pipe conforming to the requirements for top and brace rails.
2. The construction of the frame shall be welded or assembled with corner fittings. The frame shall be rigid and to the extent necessary to maintain a 2-inch clearance between bottom of the frame and finish grade. If necessary to maintain rigidity, attach to the frame a series of 3/8-inch diameter galvanized steel pipe stakes that are embedded a minimum of 2 feet to the sides and bottom of the ditch.
3. Attach chain link fabric securely to frame at intervals not exceeding 12 inches.

3.02 PREPARATION

A. Clear area on either side of fence to the extent specified in Section 31 10 00, Site Clearing. Eliminate ground surface irregularities along fence line to the extent necessary to maintain a 2-inch clearance between bottom of fabric and finish grade.

B. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Embedment Coating: Coat portion of galvanized or aluminum-coated steel posts that will be embedded in concrete as specified in Section 09 90 00, Painting and Coating. Extend coating 1 inch above top of concrete.

3.03 POST SETTING

A. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are not acceptable. Postholes shall be clear of loose materials. Waste materials from postholes shall be removed from Site or regraded into slopes on Site.

B. Posthole Depth:

1. Minimum 3 feet below finished grade.

2. 2 inches deeper than post embedment depth below finish grade.

C. Set posts with minimum embedment below finished grade of 34 inches and with top rail at proper height above finished grade. Verify posts are set plumb, aligned, and at correct height and spacing. Brace posts, as necessary, to maintain correct position and plumbness until concrete sets.

D. Backfill postholes with concrete to 2 inches above finished grade. Vibrate or tamp concrete for consolidation. Protect above ground portion of posts from concrete splatter.

E. Before concrete sets, crown and finish top of concrete to readily shed water.

F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.

G. Line Posts: Space line posts uniformly at 10 feet on centers between terminal end, corner, and gate posts.

3.04 POST BRACING

A. Install according to ASTM F567, maintaining plumb position, and alignment of fencing. Install braces at gate, end, pull, and corner posts diagonally to adjacent line posts to ensure stability. Install braces on both sides of corner and pull posts.

1. Locate horizontal braces at mid-height of fabric or higher, on fences with top rail, and 2/3-fabric height on fences without top rail. Install so posts are plumb when diagonal truss rod assembly is under proper tension.

3.05 TOP RAILS

A. Install according to ASTM F567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.06 BARBED WIRE SUPPORTING ARMS

A. Barbed wire supporting arms shall be installed as indicated and as recommended by manufacturer. Bolt or rivet supporting arm to top of post in a manner to prevent easy removal with hand tools. Angle single arms to outside of fence.

3.07 TENSION WIRE

A. Install according to ASTM F567 and ASTM F1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with tie wires at a maximum spacing of 24 inches on center.

B. Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

3.08 CHAIN LINK FABRIC

A. Do not install fabric until concrete has cured minimum 7 days.

B. Apply fabric to outside of enclosing framework. Pull fabric taut to provide a smooth and uniform appearance free from sag, without permanently distorting fabric diamond or reducing fabric height. Tie fabric to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

C. Splicing shall be accomplished according to ASTM F1916 by weaving a single picket into the ends of the rolls to be joined.

D. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.

E. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches on center.

F. Tie Wires: Fasten ties to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends of tie wire three full twists, and cut off protruding ends to preclude untwisting by hand.

1. Maximum Spacing: Tie fabric to line posts at 12 inches on center and to brace and top rails at 24 inches on center.

3.09 BARBED WIRE

A. Install barbed wire uniformly in configurations of three strands of barbed wire on supporting arms. Pull wire taut and install securely to supporting arms and secure to end terminal post or terminal arms.

3.10 BARBED TAPE

A. Install barbed tape uniformly on top of the barbed wire and V-shaped supporting arms in the configuration shown on Drawings. Secure each loop to arms or single strand of barbed wire to prevent movement or displacement according to ASTM F1911.

3.11 ELECTRICAL GROUNDING

A. Ground fences at a maximum interval of 1,000 feet in accordance with applicable requirements of IEEE C2, National Electrical Safety Code.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

3.12 FIELD QUALITY CONTROL

A. Post and Fabric Testing: Test fabric tension and line post rigidity according to ASTM F1916.

3.13 CLEANUP

A. Remove excess fencing materials and other debris from Site.

END OF SECTION

SECTION 32 91 13
SOIL PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
    a. C33, Standard Specification for Concrete Aggregates.
    b. C602, Standard Specification for Agricultural Liming Materials.
2. U.S. Bureau of Reclamation (USBR):
    a. 514.4.4, Reclamation Instructions, Series 510—Land Classification Techniques and Standards, Part 514—Laboratory Procedures, Chapter 4—Particle-Size Analyses.
    b. 514.8.7, Reclamation Instructions, Series 510—Land Classification Techniques and Standards, Part 514—Laboratory Procedures, Chapter 8—Soil Chemical Tests.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Product labels/data sheets.

B. Informational Submittals:

1. Certified Topsoil Analysis Reports:
    a. Indicate quantities of materials necessary to bring topsoil into compliance with textural/gradation requirements.
    b. Indicate quantity of lime, and quantity and analysis of fertilizer.

1.03 SEQUENCING AND SCHEDULING

A. Rough grade areas to be planted or seeded prior to performing Work specified under this section.

PART 2 PRODUCTS

2.01 TOPSOIL

A. General: Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

B. Composition: As determined in accordance with USBR 514.4.4:

1. Gravel-Sized Fraction: Maximum 80 percent by weight retained on a No. 10 sieve.
2. Sand-Sized Fraction: Maximum 65 percent passing No. 10 sieve and retained on No. 270 sieve.
3. Silt-Sized Fraction: Maximum 50 percent passing No. 270 sieve and larger than 0.002 millimeter.
4. Clay-Sized Fraction: Maximum 25 percent smaller than 0.002 millimeter.

C. Organic Matter: Minimum 1.5 percent by dry weight as determined in accordance with USBR 514.8.7.

D. pH: Range 6.0 to 7.2.

E. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

F. Source: Stockpile material onsite, in accordance with Section 31 10 00, Site Clearing. Import topsoil if onsite material fails to meet specified requirements or is insufficient in quantity.

2.02 LIME

A. Composition: Ground limestone with not less than 85 percent total carbonates, ASTM C602.

B. Gradation:

1. Minimum 50 percent passing No. 100 sieve.
2. Minimum 90 percent passing No. 20 sieve.
3. Coarser material acceptable provided rates of application are increased proportionately on basis of quantities passing No. 100 sieve.

2.03 SAWDUST OR GROUND BARK

A. Nontoxic, of uniform texture, and subject to slow decomposition when mixed with soil. Nitrogen-treated, or if untreated mix with minimum 0.15 pound of ammonium nitrate or 0.25 pound of ammonium sulfate per cubic foot of loose material.

2.04 PEAT

A. Composition: Natural residue formed by decomposition of reeds, sedges, or mosses in a freshwater environment, free from lumps, roots, and stones.

1. Organic Matter: Not less than 90 percent on a dry weight basis as determined by USBR 514.8.7.
2. Moisture Content: Maximum 65 percent by weight at time of delivery.

2.05 FERTILIZER

A. Manure:

1. Well-rotted, stable or cattle manure, free from weed seed and refuse.
2. Maximum 50 percent sawdust or shavings by volume.
3. Age: Minimum 4 months; maximum 2 years.

2.06 SAND

A. Fine Aggregate: Clean, coarse, well-graded, ASTM C33.

2.07 SOURCE QUALITY CONTROL

A. Topsoil Analysis/Testing: Performed by county extension agent.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. Apply lime at the rate of 50 pounds per 1,000 square feet to subgrade before tilling.

B. Scarify subgrade to minimum depth of 6 inches where topsoil is to be placed.

C. Remove stones over 2-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous material.

D. Limit preparation to areas which will receive topsoil within 2 days after preparation.

3.02 TOPSOIL PLACEMENT

A. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

B. Mix soil amendments, lime, and fertilizer with topsoil before placement or spread on topsoil surface and mix thoroughly into entire depth of topsoil before planting or seeding. Delay mixing of fertilizer if planting or seeding will not occur within 3 days.

C. Place 1/2 of total depth of topsoil and work into top 4 inches of subgrade soil to create a transition layer. Place remainder of topsoil to depth as shown after compacting to 75 percent where seeding and planting are scheduled.

D. Uniformly distribute to within 1/2 inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.

E. Remove stones exceeding 1-1/2 inches, roots, sticks, debris, and foreign matter during and after topsoil placement.

F. Remove surplus subsoil and topsoil from Site. Grade stockpile area as necessary and place in condition acceptable for planting or seeding.

END OF SECTION

SECTION 32 92 00
TURF AND GRASSES

PART 1 GENERAL

1.01 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted (seed, sod, or sprig) and continue for a period of 8 weeks after all planting under this section is completed.

B. Satisfactory Stand: Grass or section of grass that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.02 SUBMITTALS

A. Action Submittals: Product labels/data sheets.

B. Informational Submittals:

1. Seed: Certification of seed analysis, germination rate, and inoculation:
   a. Certify that each lot of seed has been tested by a testing laboratory certified in seed testing, within 6 months of date of delivery. Include with certification:
      1) Name and address of laboratory.
      2) Date of test.
      3) Lot number for each seed specified.
      4) Test Results: (i) name, (ii) percentages of purity and of germination, and (iii) weed content for each kind of seed furnished.
   b. Mixtures: Proportions of each kind of seed.
2. Seed Inoculant Certification: Bacteria prepared specifically for legume species to be inoculated.
3. Certification of sod; include source and harvest date of sod, and sod seed mix.
4. Certification of sprig type and name.
5. Description of required maintenance activities and activity frequency.

1.03 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Sod:

1. Do not harvest if sod is excessively dry or wet to the extent survival may be adversely affected.
2. Harvest and deliver sod only after laying bed is prepared for sodding.
3. Roll or stack to prevent yellowing.
4. Deliver and lay within 24 hours of harvesting.
5. Keep moist and covered to protect from drying from time of harvesting until laid.

C. Sprigs:

1. Cut and deliver only after planting area is prepared for planting.
2. Deliver and plant within 24 hours of harvesting.
3. Keep moist and covered to protect from drying from time of cutting until planted.

D. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.04 WEATHER RESTRICTIONS

A. Perform Work under favorable weather and soil moisture conditions as determined by accepted local practice.

1.05 SEQUENCING AND SCHEDULING

A. Complete Work specified in MP-C-107 and prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.

B. Complete Work under this section within 14 days following completion of soil preparation.

C. Notify Engineer at least 3 days in advance of:

1. Each material delivery.
2. Start of planting activity.

D. Planting Season: Those times of year that are normal for such Work as determined by accepted local practice.

1.06 MAINTENANCE SERVICE

A. Contractor: Perform maintenance operations during maintenance period to include:

1. Watering: Keep surface moist.
2. Washouts: Repair by filling with topsoil, liming, fertilizing, seeding, and mulching.
3. Mulch: Replace wherever and whenever washed or blown away.
4. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.
5. Fences: Repair and maintain until satisfactory stand of grass is established.
6. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
7. Reseed/replant during next planting season if scheduled end of maintenance period falls after October 15.
8. Reseed/replant entire area if satisfactory stand does not develop by July 1 of the following year.

PART 2 PRODUCTS

2.01 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose. Minimum percentage of plant food by weight.

B. Application Rates: Determined by soil analysis results.

C. Mix: determined by local consultation with county extension agent.

D. Top Dress Type: As recommended by county extension agent.

2.02 SEED

A. Fresh, clean new-crop seed that complies with the tolerance for purity and germination established by Official Seed Analysts of North America.

B. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer's instructions.

C. Summer Seed Mix: All areas to be restored shall be seeded with the following mixture: (percentages are by weight.)
40% Kentucky Bluegrass (Poa pratensis)
40% Creeping Red Fescue (Festuca rubra)
20% Annual Ryegrass (Lolium multiflorum)

D. Winter Protective Seed: If needed, determined by local consultation with county extension agent.

2.03 SOD

A. Certified, local, containing grass mix: as recommended by county extension agent.

B. Strongly rooted pads, capable of supporting own weight and retaining size and shape when suspended vertically from a firm grasp on upper 10 percent of pad.

1. Grass Height: Normal.
2. Strip Size: Supplier's standard.
3. Soil Thickness: Uniform; 1 inch plus or minus 1/4 inch at time of cutting.
4. Age: Not less than 10 months or more than 30 months.
5. Condition: Healthy, green, moist; free of diseases, nematodes and insects, and of undesirable grassy and broadleaf weeds. Yellow sod, or broken pads, or torn or uneven ends will not be accepted

2.04 SPRIGS

A. Healthy living stems (stolons or rhizomes) of grass species harvested without adhering soil and obtained from sources where sod is heavy and thickly matted.

B. Free of noxious weeds or other growth detrimental to economical maintenance, proper establishment, or appearance of completed lawn.

2.05 STRAW MULCH

A. Threshed straw of oats, wheat, barley, or rye, free from (i) seed of noxious weeds or (ii) clean salt hay.

2.06 HYDROSEEDING MULCH

A. Wood Cellulose Fiber Mulch:

1. Specially processed wood fiber containing no growth or germination inhibiting factors.
2. Dyed a suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

2.07 NETTING

A. Jute: Heavy-duty, twisted, weighing pounds per square yard.

1. Openings Between Strands: Approximately inch square.

B. Plastic:

1. Extruded Polypropylene: 20 mils.
2. Opening Between Strands: 1 inch by 2 inch.

C. Matting: Excelsior mat or straw blanket; staples as recommended by matting manufacturer.

1. Manufacturers and Products:
   a. Akzo Industries, Ashville, NC; Curlex mat.
   b. North American Green, Evansville, IN; S150 blanket.

2.08 TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

1. Capable of hydrating in water, and to readily blend with other slurry materials.
2. Wood Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.
3. Manufacturers and Products:
   a. Chevron Asphalt Co.; CSS 1.
   b. Terra; Tack AR.
   c. J Tack; Reclamare.

2.09 FENCE

A. 2-inch by 2-inch posts 4 feet high, spaced 10 feet on center, and strung with single strand of No. 12 gauge wire marked with cloth strips at 3-foot intervals.

2.10 WEED BARRIER

A. 6 mils (0.006 inch) black polyethylene sheet.

2.11 DIVIDER

A. Cedar, Standard or Better Grade.

2.12 EDGING

A. Steel: 1/4 inch by 5 inches wide in 15-foot minimum lengths, manufacturer's standard black, with 18-inch long steel stakes and fastenings on curb.

B. Plastic: Polyethylene edging 1/8 inch by 4 inches wide, black, with integral design to provide a firm hold without staking.

PART 3 EXECUTION

3.01 PREPARATION

A. Grade areas to smooth, even surface with loose, uniformly fine texture.

1. Roll and rake, remove ridges, fill depressions to meet finish grades.
2. Limit such Work to areas to be planted within immediate future.
3. Remove debris, and stones larger than 1-1/2-inch diameter, and other objects that may interfere with planting and maintenance operations.

B. Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface to dry off before seeding. Do not create muddy soil.

C. Restore prepared areas to specified condition if eroded or otherwise disturbed after preparation and before planting.

3.02 FERTILIZER

A. Apply evenly over area in accordance with manufacturer's instructions. Mix into top 2 inches of topsoil.

B. Application Rate: Determined by soil test results in accordance with Section 32 91 13, Soil Preparation.

3.03 SEEDING

A. Start within 2 days of preparation completion.

B. Hydroseed slopes steeper than3:1. Flatter slopes may be mechanically seeded.

C. Mechanical: Broadcast seed in two different directions, compact seeded area with cultipacter or roller.

1. Sow seed at uniform rate of in accordance with county extension agent recommendations..
2. Use Brillion type seeder.
3. Broadcasting will allowed only in areas too small to use Brillion type seeder. Where seed is broadcast, increase seeding rate 20 percent.
4. Roll with ring roller to cover seed, and water with fine spray.

D. Hydroseeding:

1. Application Rate: In accordance with county extension agent recommendations.
2. Apply on moist soil, only after free surface water has drained away.
3. Prevent drift and displacement of mixture into other areas.
4. Upon application, allow absorption and percolation of moisture into ground.
5. Mixtures: Seed and fertilizer may be mixed together, apply within 30 minutes of mixing to prevent fertilizer from burning seed.

E. Cover Crop Seeding: Apply seed at rate of 120 pounds per acre to areas that are bare or incomplete after October 15.

F. Mulching: Apply uniform cover of straw mulch at a rate of 2 tons per acre.

G. Netting: Immediately after mulching, place over mulched areas with slopes steeper than 3:1, in accordance with manufacturer's instructions. Locate strips parallel to slope and completely cover seeded areas.

H. Water: Apply with fine spray after mulching to saturate top 4 inches of soil.

3.04 SODDING

A. Do not plant dormant sod, or when ground is frozen.

B. Lay sod to form solid mass with tightly fitted joints; butt ends and sides, do not overlap.

1. Stagger strips to offset joints in adjacent courses.

2. Work from boards to avoid damage to subgrade or sod.
3. Tamp or roll lightly to ensure contact with subgrade; work sifted soil into minor cracks between pieces of sod, remove excess to avoid smothering adjacent grass.
4. Complete sod surface true to finished grade, even, and firm.

C. Fasten sod on slopes to prevent slippage with wooden pins 6 inches long driven through sod into subgrade, until flush with top of sod. Install at sufficiently close intervals to securely hold sod.

D. Water sod with fine spray immediately after planting. During first week, water daily or more frequently to maintain moist soil to depth of 4 inches.

E. Apply top dress fertilizer at recommended rate.

3.05 SPRIGGING

A. Plant individual root clusters with roots and portions of stem buried in soil, but do not cover growing tips. Firm soil around sprigs after planting.

B. Furrows:

1. Dig at minimum of 6 inches on centers and open to depth of not less than 3 to 4 inches.
2. Open furrows at right angles to direction of slopes.

C. As soon as furrows are opened, place sprigs in continuous rows by hand.

D. Place sprigs at not more than 6 inches on centers, and stagger sprigs in alternate rows.

E. Cover sprigs with soil as soon as possible but no later than 30 minutes after placing in furrows.

F. Level and roll by mechanical or hand methods to even surface and to grade.

G. Water sprigs immediately after planting and keep moist by frequent watering until well rooted.

3.06 FIELD QUALITY CONTROL

A. 8 weeks after seeding is complete and on written notice from Contractor, Engineer will, within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Engineer will make another determination after written notice from Contractor following the next growing season.

3.07 PROTECTION

A. Protect from pedestrian traffic by erecting temporary fence around each newly seeded area.

END OF SECTION

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SECTION 33 05 01
CONVEYANCE PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 301, Standard Specification for Structural Concrete.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in. (75 mm Through 1200 mm), for Water and Other Liquids.
   b. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
   d. C210 Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   e. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   f. C217, Cold-Applied Petroleum Tape and Petroleum Wax Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Buried Steel Water Pipelines.
   g. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   h. C221, Fabricated Steel Mechanical Slip-Type Expansion Joints.
   i. C606, Grooved and Shouldered Joints.
3. ASTM International (ASTM):
   a. A497, Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
   b. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   c. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   d. C150, Standard Specification for Portland Cement.
   e. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
4. NSF International (NSF): 61B, Drinking Water System Components - Health Effects.

1.02 DESIGN REQUIREMENTS

A. Ductile iron pipe shall be manufactured in accordance with AWWA C151. All pipe, except specials, shall be furnished in nominal lengths of 18 to 20 feet. Sizes will be as shown on the Drawings. All pipe shall have a minimum pressure rating as indicated in the following table, and corresponding minimum wall thickness, unless otherwise specified or shown on the Drawings:

Pipe Sizes (inches)	Pressure Class (psi)
4 – 12	350
14 – 18	350
20	300
24	250
30 - 42	200

1.03 SUBMITTALS

A. Action Submittals:

1. Detailed pipe fabrication drawings showing pipe details, special fittings and bends, dimensions, coatings, and other pertinent information.
2. Layout drawing showing location of each pipe section and each special length.
3. Pipe pressure class.
4. Wall thickness, reinforcing, and strength calculations.
5. Product Data: Manufacturer's data for couplings, saddles, gaskets, and other pipe accessories. Indicate maximum rated working pressure and test pressure for each item.

B. Informational Submittals: Provide manufacturer's certificate(s) in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with manufacturer's recommendations.

B. Marking at Plant: Mark each pipe and fitting at plant. Include date of manufacture, manufacturer's identification, specification standard, diameter of pipe, pipe class, and other information required for type of pipe.

C. Pipe, specials, and fittings received at Project Site in damaged condition will not be accepted.

D. Gasket Storage: Store rubber gaskets in cool, well ventilated place, and do not expose to direct rays of sun. Do not allow contact with oils, fuels, petroleum, or solvents.

E. Store and support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.

F. Handling:

1. Pipe shall be handled with proper equipment in a manner to prevent distortion or damage. Use of hooks, chains, wire ropes, or clamps that could damage pipe, damage coating or lining, or kink and bend pipe ends is not permitted.
2. Use heavy canvas, or nylon slings of suitable strength for lifting and supporting materials.
3. Lifting pipe during unloading or lifting into trench shall be done using two slings placed at quarter point of pipe section. Pipe may be lifted using one sling near center of pipe, provided pipe is guided to prevent uncontrolled swinging and no damage will result to pipe or harm to workers. Slings shall bear uniformly against pipe.
4. Pipe and fittings shall not be stored on rocks or gravel, or other hard material that might damage pipe. This includes storage area and along pipe trench.

PART 2 PRODUCTS

2.01 PIPE

A. As specified in the individual Specification(s) following this section.

2.02 JOINTS

A. As specified in the individual Specification(s) following this section.

2.03 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF 61B.
2. Couplings shall be rated for appropriate operating pressure and hydrostatic test pressure.

3. Exposed, bolted, sleeve-type couplings shall be lined and coated with fusion bonded epoxy in accordance with AWWA C213.
4. Buried, bolted, sleeve-type couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213.

B. For Pipe with Plain-Ends:

1. Bolted, sleeve-type coupling, in accordance with AWWA C219.
    a. Manufacturer of couplings shall observe same quality control requirements as specified in AWWA C221 for fabrication of pipe expansion joints.
    b. Unless thrust restraint is provided by other means, bolted, sleeve-type couplings shall be harnessed. Harness details shall be in accordance with requirements of appropriate reference standard or as shown on Drawings.
    c. Certified Welding Inspector at coupling fabrication facility shall verify welders and welding procedures are qualified, procedures are being followed, and quality assurance functions are being implemented.
2. Fabricated steel, mechanical slip-type expansion joints, in accordance with AWWA C221.
3. Depend-O-Lok couplings as manufactured by Victaulic Depend-O-Lok, Inc.

C. For Pipe with Grooved Ends:

1. Grooved couplings, in accordance with AWWA C606. System shall provide for flexible or rigid joints as shown on Drawings.
2. Exposed couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210.
3. Buried couplings shall be lined and coated with and wrapped with petroleum wax tape in accordance with AWWA C217.

D. For Pipe with Flanged Ends:

1. Flanged coupling adapters, in accordance with AWWA C219.
2. Dismantling joints for connecting flanged pipe shall be AWWA C219 compliant. Provide studs and nuts to seal gasket separate and independent from tie-bar restraint system.
3. Rubber expansion joints shall allow compression, extension, and lateral deflection of the pipes being joined.
    a. Joints shall be suitable for use with potable water.

E. Bolting Materials for Couplings: In accordance with the applicable AWWA standard.

2.04 SERVICE SADDLES

A. Double strap design rated for 150 psi minimum working pressure.

2.05 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Assemble interconnected rubber links with Type 316 stainless steel bolts, nuts, and pressure plates.
3. Size modular mechanical seals according to manufacturer's instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening.
4. Manufacturers and Products:
   a. Thunderline/LinkSeal, Div. Of PSI, Houston, TX; Link Seal.
   b. Calpico, Inc., South San Francisco, California; Sealing Linx.
   c. Advance Products and Systems, Lafayette, Louisiana; Innerlynx.

B. Wall Sleeves:

1. Diameter, ends, and length shall be as shown on Drawings.
2. Shall include integral seep ring to minimize seepage between metal sleeve and concrete.

C. Wall Couplings:

1. Diameter, ends, and length shall be as shown on Drawings.
2. Wall couplings shall provide flexible mechanical joint.
3. Body and end rings shall be coated with fusion bonded epoxy.
4. Body shall include integral seep ring.
5. Shall comply with AWWA C219.

D. If core drilling is required for penetrations of existing concrete walls or slabs, locations of drilling shall be determined by radiograph to avoid damage to reinforcing steel and conduits.

2.06 FLANGES, FLANGE GASKETS, AND BOLTING MATERIALS

A. As specified in individual specifications following this section.

B. Flanges, bolting materials, and flange gaskets for steel flanges shall conform to AWWA C207.

C. Flanges, bolting materials, and flange gaskets for ductile iron flanges shall conform to AWWA C110 and AWWA C115.

D. If the flanges are coated, provide two washers for each bolt on each side of the flange to minimize damage to the coating as the nuts are tightened. Provide bolts of the proper length to accommodate the washers.

2.07 CONCRETE FOR THRUST BLOCKS

A. Thrust Block Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing Steel: ASTM A615/A615M, Grade 60 deformed bars.

C. Welded Wire Fabric: ASTM A497.

D. Formwork: Plywood.

2.08 PIPE LOCATING TAPE

A. As specified in Section 31 23 23.15, Trench Backfill.

2.09 PIPE BEDDING AND PIPE ZONE MATERIAL

A. Granular material or Controlled low strength material as specified in Section 31 23 23.15, Trench Backfill.

2.10 TRENCH STABILIZATION MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

PART 3 EXECUTION

3.01 GENERAL

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Furnish feeler gauges of proper size, type, and shape for use during installation for each type of pipe furnished.

C. Distributing Materials: Place materials along trench only as will be used each day, unless otherwise approved by Engineer. Placement of materials shall not be hazardous to traffic or to general public, obstruct access to adjacent property, or obstruct others working in area.

3.02 EXAMINATION

A. Verify size, material, joint types, elevation, and horizontal location of existing pipeline to be connected to new pipeline or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Damaged Coatings and Linings: Repair using coating and lining materials in accordance with manufacturer's instructions.

3.03 PRE-TRENCHING POTHOLING

A. Contractor shall field verify location and depth of all existing utilities prior to trench excavations.

B. For all proposed pipelines size 12 inches and larger that are within or north of the main entrance driveway extended to clarifier no. 4 the Contractor shall stake the centerline of such pipelines and prior to any trench excavation on a particular pipeline shall make "pothole excavations" to a depth of at least 12 inches below the planned invert of the proposed pipeline at a spacing of 25 feet along the centerline of the pipeline. In addition to the required potholes at 25 feet spacing the Contractor shall also do potholes on the proposed pipeline centerline at locations where the drawings indicate the proposed pipeline crosses an existing buried pipeline or conduit.

C. "Pothole excavations" shall be done with vacuum excavation equipment or other similar equipment designed for limited exploratory excavations in utility construction.

D. No trench excavation for pipeline construction shall be done for a given pipeline until potholing has been completed along its centerline and the results evaluated by the Contractor for potential conflicts with the planned location of the proposed pipeline. Should potholing results identify potential conflicts with the planned location of proposed pipelines the Contractor shall review the results with the Owner and Engineer prior to beginning any trench excavation to determine what adjustments, if any, are required.

E. Total number of potholing locations to be included in Contact lump sum price shall be 90 locations. "

3.04 PREPARATION OF TRENCH

A. Prepare trench as specified in Section 31 23 16, Excavation.

B. Unless otherwise permitted by Engineer, maximum length of open trench shall not exceed 50 feet.

3.05 INSTALLATION

A. General:

1. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
2. Install individual pipe lengths in accordance with approved lay diagram. Misplaced pipe shall be removed and replaced.
3. Inspect pipe and fittings before installation, clean ends thoroughly, remove foreign matter and dirt from inside.
4. Flanged Joints:
   a. Install perpendicular to pipe centerline.
   b. Bolt Holes: Straddle vertical centerline, aligned with connecting equipment flanges or as shown on Drawings.
   c. Use torque-limiting wrenches to provide uniform bearing and proper bolt tightness.
   d. Flange Type: Use flat-faced flange when joining with flat-faced ductile or cast iron flange.
5. Couplings:
   a. Install in accordance with manufacturer's written instructions.
   b. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
   c. Clean gaskets before installation.
   d. If necessary, lubricate with gasket lubricant for installation on pipe ends.
   e. Tighten coupling bolts progressively, drawing up bolts on opposite sides gradually until bolts have uniform tightness.

B. Buried Pressure Pipe:

1. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown on Drawings.
2. Placement:
   a. Keep trench dry until pipe laying and joining is completed.
   b. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
   c. Measure for grade at pipe invert, not at top of pipe.
   d. Excavate trench bottom and sides of ample dimensions to permit proper joining, welding, visual inspection, and testing of entire joint.
   e. Prevent foreign material from entering pipe during placement.

f. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
g. In general, lay pipe upgrade with bell ends pointing in direction of laying.
h. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    1) Shorter pipe lengths.
    2) Special mitered joints.
    3) Standard or special fabricated bends.
i. Check gasket position with feeler gauge to assure proper seating.
j. After joint has been made, check pipe alignment and grade.
k. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
l. Prevent uplift and floating of pipe prior to backfilling.

3. Tolerances:
    a. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Cover Over Top of Pipe: Minimum 3 feet, unless otherwise shown.
5. Disposal of Excess Excavated Material: As specified in Section 31 23 16, Excavation.
6. Contractor shall take necessary measures to prevent pipe floatation for the period between installation and initiation of service.

3.06 THRUST RESTRAINT

A. Location: At pipeline tees, plugs, caps, bends, and locations where unbalanced forces exist.

B. Thrust Blocking:

1. Place only where shown on Drawings.
2. Quantity of Concrete: Sufficient to cover bearing area of pipe and provide required soil bearing area as shown on Drawings.
3. Place blocking so pipe and fitting joints are accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, Cast-in-Place Concrete ACI 301.

3.07 CORROSION PROTECTION

A. Buried Pipe: As specified in the individual specifications following this section.

B. Notify Engineer at least 3 days prior to start of surface preparation, coating application, and corrosion protection work.

3.08 PLACEMENT OF PIPE LOCATING TAPE

A. Place pipe locating tape in accordance with Section 31 23 23.15, Trench Backfill.

3.09 PIPE BEDDING AND ZONE MATERIAL

A. Place pipe bedding and pipe zone material in accordance with Section 31 23 23.15, Trench Backfill.

3.10 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in the individual Specification(s) following this section.

3.11 CLEANING AND DISINFECTION

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines with water at 2.5 fps recommended flushing velocity until foreign matter is removed. Dispose of water and flushed foreign matter.

B. If impractical to flush large diameter pipe at 2.5 fps, clean pipe in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

C. Remove accumulated debris through blowoffs 2 inches and larger or by removing spools and valves from piping.

D. Disinfection: As specified in Section 33 13 00, Disinfecting of Water Utility Distribution.

END OF SECTION

SECTION 33 05 01.02
DUCTILE IRON PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. T99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5LB) Hammer and a 305mm (12 in.) Drop.
2. American Water Works Association (AWWA):
   a. C104, Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.
   b. C105, Polyethylene Encasement for Ductile Iron Pipe Systems.
   c. C110, Ductile Iron and Grey Iron-Fittings, 3-inch through 48-inch.
   d. C111, Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
   e. C115, Flanged Ductile Iron Pipe with Ductile Iron and Grey Iron Fittings.
   f. C150, Thickness Design of Ductile-Iron Pipe.
   g. C151, Ductile-Iron Pipe. Centrifugally Cast, for Water.
   h. C153, Ductile Iron Compact Fittings, 3-inch through 24-inch and 54-inch through 64-inch for Water Service.
   i. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4-inch Through 144-inch (100mm through 3600mm).
   j. C600, Installation of Ductile-Iron Water Mains and Their Appurtenances.
   k. C606, Grooved End, Shouldered Joints.
3. ASTM International (ASTM)
   a. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   b. A563, Standard Specification for Carbon and Alloy Steel Nuts.
   c. B16.21, Standard Specification for Nonmetallic Flat Gaskets for Pipe Flanges.
   d. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
   e. D1330, Standard Specification for Rubber Sheet Gaskets.
   f. D1922, Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method.

g. D2000, Standard Classification System for Rubber Products in Automotive Applications.
h. D4976, Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.

4. Ductile Iron Pipe Research Institute (DIPRA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Marking plan and details of standard pipe section showing dimensions, pipe joints, fitting and special fitting pressure rating and thickness, size, coating and lining data.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, stating that inspections and specified tests have been made and that results thereby comply with requirements of Article Source Quality Control.
2. Field Hydrostatic Testing Plan: Submit at least 15 days prior to testing and at minimum, include the following:
   a. Testing dates.
   b. Piping systems and section(s) to be tested.
   c. Method of isolation.
   d. Method of conveying water from source to system being tested.
   e. Calculation of maximum allowable leakage for piping section(s) to be tested.
3. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
4. Test documentation form and results.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe:

1. General:
   a. Centrifugally cast, grade 60-42-10 iron.
   b. Meet requirements of AWWA C150, C153 and C111.
   c. Lined and coated as specified.

2. Pressure rating of pipe is as identified in table below:

Pipe Sizes (inches)	Pressure Class (psi)
4 – 12	350
14 – 18	350
20	300
24	250
30 - 42	200

3. Pipe wall thickness of threaded pipe for a flanged pipe end shall be minimum special thickness Class 53 from 12-inch to 54-inch diameter pipe in accordance with AWWA C115.
4. Grooved end pipe, for all pipe diameters, shall be minimum Special Class 53.
5. Pipe shall be new and recently manufactured. Refurbished pipe shall not be provided.

B. Joints:

1. Push-On Joint: Rated at minimum working pressure equal to pipe material design.
2. Restrained Joint:
   a. Manufactured proprietary joint that mechanically restrains pipe to adjoining pipe.
   b. Manufacturers and Products:
      1) American Cast Iron Pipe; Flex-Ring and Lok-Ring.
      2) Pacific States Pipe; Thrust-Lock.
      3) U.S. Pipe; TR Flex.
3. Mechanical Wedge Action Type Joint:
   a. Use only in areas where adjoining to fixed points where laying length is determined in field.
   b. Prior to purchase and installation, type and application of this joint shall be approved by Engineer.
4. Use of set screws for restraint or field-lock gaskets shall not be allowed.
5. Flanged Joint: Threaded 250 psi working pressure ductile iron flanges conforming to AWWA C115.
6. Grooved Joint:
   a. Rigid type radius cut grooved, conforming to AWWA C606.
   b. As manufactured by Victaulic Company of America.

C. Fittings:

1. Ductile Iron, Push-On, Flanged or Restrained Joint: In accordance with AWWA C110, at 250 psi minimum working pressure for 3- to 24-inch fittings and 150 psi minimum working pressure for 30- to 48-inch fittings.
2. Mechanical Joint Fittings: In accordance with AWWA C111.
3. Grooved End Fittings:
   a. Radius cut grooved, rigid type conforming to AWWA C110 and AWWA C153.
   b. Manufacturers:
      1) Victaulic Company of America.
      2) Gustin-Bacon.
4. Fittings shall be new and recently manufactured. Refurbished fittings will not be accepted.

D. Welded Outlet: Only weld to pipe in manufacturer's shop.

E. Lining:

1. Pipe and fittings for clean water applications shall be cement-lined and asphaltic seal coated in accordance with AWWA C104.

F. Coating: Asphaltic type, 1 mil thick, in accordance with AWWA C151, C115, C110 and C153.

G. Polyethylene Encasement:

1. Virgin polyethylene raw material conforming to requirements of ASTM D4976.
2. Elongation: 800 percent, minimum, in machine and transverse direction (ASTM D882).
3. Tensile Strength: 3,600 psi, minimum.
4. Dielectric Strength: 800V per mil-thickness, minimum.
5. Propagation Tear Resistance: 2,550-grams force (gf), minimum, in machine and transverse direction (ASTM D1922).
6. Tube form, conforming to AWWA C105.
7. Film shall have minimum thickness of 0.008 inch (8 ml).

H. Bolting:

1. Bolts for flanged connections shall be carbon steel, ASTM A307, Grade A hex bolts and ASTM A563, Grade A hex head nuts.
2. Bolts for grooved end connections shall be manufacturer's standard.

I. Gaskets:

1. Gaskets for flat faced 150 and 250 psi working pressure flanges shall be 1/8 inch thick, red rubber (SBR), hardness 80 (Shore A), rated to 200 degrees F, conforming to ASME B16.21, AWWA C207, and ASTM D1330, Grades 1 and 2.
2. Gaskets for grooved end joints shall be Halogenated butyl, conforming to ASTM D2000 and AWWA C606.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect pipe and fittings to ensure no cracked, broken, or otherwise defective materials are being used.

3.02 PREPARATION

A. Trench Grade:

1. Grade bottom of trench by hand to specified line and grade, with proper allowance for pipe thickness and pipe base, when specified. Trench bottom shall form a continuous and uniform bearing and support for pipe between bell holes.
2. Before laying each section of pipe, check grade and correct irregularities found. Grade may be disturbed for removal of lifting tackle.

B. Pipe Bedding: Place and compact pipe bedding material as detailed in Section 31 23 23B (Fill and Backfill) and 31 23 23.15B (Trench Backfill).

C. Bell (Joint) Holes: At each joint, dig bell holes of ample dimensions in bottom of trench, and at sides where necessary, to permit joint to be made properly and to permit easy visual inspection of entire joint.

3.03 INSTALLATION

A. General:

1. Provide and use proper implements, tools, and facilities for safe and proper prosecution of Work.
2. Lower pipe, fittings, and appurtenances into trench, piece by piece, by means of a crane, slings, or other suitable tools and equipment, in such a manner as to prevent damage to pipe materials, protective coatings and linings.
3. Do not drop or dump pipe materials into trench.

C. Steel Plate Fittings and Specials:

1. Fabricated from steel plate, cement-mortar lined and coated.
2. Steel plate fittings shall conform to dimensional requirements of AWWA C208.
3. Minimum Steel Plate Thickness: 1/4 inch or diameter divided by 120, whichever is greater.
4. Line and coat steel fittings in accordance with AWWA C205.

D. Minimum Wall Thickness: Select from C361 Table 1, but in any case, no less than 3 inches or that required by ASTM C76 Class IV, for Wall B pipe, whichever is greatest. For diameters greater than 72 inches, provide thickest wall listed in ASTM 361 Table 1.

E. Cement:

1. ASTM C150, Type II.
2. Fly ash or other cement substitutes will not be allowed.
3. Minimum Cement Content: 564 pounds per cubic yard.
4. Maximum Water to Cement Ratio by Weight: 0.49.

F. Concrete Strength: 4,500 psi, minimum 28-day strength.

G. Circumferential Reinforcing:

1. Only circular reinforcing shall be used. Elliptical or triple cage reinforcing arrangements shall not be permitted.
2. In no case shall areas of reinforcement in each cage be less than that required by standard designs given in ASTM C361.
3. In no case, shall placement tolerances permit less than 3/4 inch of protective concrete cover over reinforcement.
4. Increase wall thickness to provide required cover and to accommodate tolerances used in fabrication.
5. Wire fabric reinforcing shall be permitted for only single cage reinforcing patterns.
6. Provide firm and positive support of reinforcing to prevent movement during concrete placement.
7. Reinforcing supports and chairs with less than 1/2 inch of concrete cover shall be corrosion resistant stainless steel or plastic coated. Wire tie ends shall be bent away from surface of concrete.

H. Longitudinal Reinforcing:

1. Full length longitudinal reinforcing for all cages

2. Equally spaced ASTM A615, Grade 40 bars. Do not consider longitudinal wires in welded wire fabric as longitudinal reinforcing.
3. Maximum Spacing: 12 inches or three times wall thickness, whichever is less, but in no case less than a total of four bars.
4. Provide a minimum total cross-sectional area of reinforcing equal to 0.004 times gross concrete area of pipe wall.
5. In no case, shall placement tolerances permit less than 3/4 inch of protective concrete cover over longitudinal reinforcement.
6. Increase wall thickness as needed to provide required cover and to accommodate tolerances used in fabrication.

I. Aggregates: Aggregates and sand shall be nonreactive and shall conform to requirements of AWWA C302.

J. Water: Clean, potable, and free of objectionable quantities of organic matter, alkali, salts, and other impurities. Agricultural water with total dissolved solids exceeding 1,000 milligrams per liter or plant recycle water shall not be used.

K. Air Entraining Agent: Conform to ASTM C260 in accordance with ASTM C361.

L. Curing: In accordance with requirements of AWWA C302.

M. Marking: Each pipe section shall be marked in accordance with requirements of ASTM C361. In addition, each pipe section shall be marked with number associated with laying diagram.

2.03 SOURCE QUALITY CONTROL

A. Provide a letter to Engineer certifying that pipe furnished meets requirements of this section.

B. Plant Testing:

1. General: Pipe shall not be coated internally or externally with any substance of any type in an attempt to improve its performance when it is air or hydrostatically tested, except that concrete gasket surfaces only may be coated with epoxy resin adhesive Sikadur 35. Other use of coating will be cause for rejection of pipe. This requirement does not apply to minor repair work on occasional imperfections resulting from manufacture or minor damage during handling.
2. Number of sections tested shall be in accordance with ASTM C361.

3. Testing shall include external pipe load testing (D-load testing), concrete compressive strength, hydrostatic testing of pipe, and hydrostatic testing of rubber gasket joints in accordance with ASTM C361.
4. Hydrostatic Test:
    a. Testing and basis of rejection shall be in accordance with ASTM C361.
    b. Sections to be tested shall be selected at random by Engineer.
    c. Hydrostatic tests shall be made on two assembled sections of pipe and shall include joint. Bulkheads shall be installed in outer ends of joined pipe sections.
    d. Sections that fail hydrostatic test shall be marked as failed sections and removed from production and storage area.
5. Manufacturing Quality Testing:
    a. Sawcut one pipe joint, randomly selected from every 100 joints of pipe manufactured, in half with a saw that will cleanly cut concrete and reinforcing steel.
    b. Cut will be inspected for voids adjacent to circumferential bars. Voids will be considered continuous and failing if a 1/16-inch diameter pin can be inserted 1/4 inch deep. If voids exist adjacent to more than 10 percent of circumferential bars, test two additional pipe sections.
    c. If either of the two additional pipe sections fail, entire lot will be rejected.

PART 3 EXECUTION

3.01 EXAMINATION

A. Manufacturing imperfections or damage caused by improper handling shall be immediately brought to attention of Engineer.

B. Repairs to pipe section shall be in accordance with procedure stated in ASTM C361 and shall be allowed, only if approved in writing by Engineer.

C. At option of Engineer, repaired pipe shall be hydrostatically tested.

D. Verify size, pipe condition, and pipe class prior to installation of pipe.

3.02 PREPARATION

A. Trench:

1. Trench bottom shall form continuous and uniform bearing and support for pipe between bell holes.
2. Check pipe bedding for uniformity of support prior to placing each section of pipe. Correct features that would cause nonuniform support prior to pipe placement.
3. Shape bedding for uniform support and provide bell holes of sufficient size at each joint to allow inspection of joint.

3.03 INSTALLATION

A. General:

1. Install pipe sections in accordance with manufacturer's recommendations.
2. Provide and use proper implements, tools, and facilities for safe and proper prosecution of Work.
3. Lower pipe, fittings, and appurtenances into trench, piece by piece, by means of crane, slings, or other suitable tools and equipment, in such a manner as to prevent damage to pipe materials, protective coatings and linings.
4. Do not drop or dump pipe materials into trench.

B. Cleaning Pipe and Fittings: Wash ends of section clean with wet brush prior to joining sections of pipe.

C. Laying Pipe:

1. Lay pipe upgrade with bell ends pointing in direction of laying, unless otherwise approved by Engineer.
2. Place pipe to specified line and grade to form smooth flow line.
3. Apply sufficient force to make joint "home", as defined in installation instructions provided by pipe manufacturer.
4. Ensure that bottom of pipe is in contact with bottom of trench for full length of each section.

D. Pipe Zone and Backfill: Whenever exterior joints are mortared or grouted, backfill over pipe shall not commence within 16 hours of joining pipe sections.

3.04 TESTS AND INSPECTIONS

A. Gasket Field Splice Tests:

1. Perform field splice test on twenty percent of each lot of delivered gaskets, in accordance with ASTM C361, in the presence of Engineer.
2. Furnish feeler gauges of proper size, type, and shape to verify proper placement of gasket.
3. Test section of gasket shall be at point where ends of gasket are joined together.
4. If gasket joints separate during test, entire lot will be rejected and shall immediately be removed from Site.

B. Pipeline Hydrostatic Test:

1. General:
   a. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.
   b. Test newly installed pipelines. Using water as test medium, pipeline shall successfully pass a leakage test prior to acceptance.
   c. Furnish testing equipment and perform tests as approved by Engineer. Testing equipment shall provide observable and accurate measurement of leakage under specified conditions.
   d. Isolate new pipelines that are connected to existing pipelines. Install pipe plugs as required to allow section of new pipe to be pressure tested.
   e. Conduct initial leakage test after five sections of pipe have been installed to confirm integrity of pipe and joints.
   f. Conduct tests on entire pipeline after trench has been backfilled. Testing may be done prior to placement of asphaltic concrete or roadway structural section.
   g. Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial service leak test. Hydrostatic test shall not, however, be conducted until backfilling has been completed.
   h. Supply of temporary water shall be as stated in Section 01 50 00, Temporary Facilities and Controls.
   i. Dispose of water used in testing.

2. Preparation:
   a. Install temporary thrust blocking or other restraint to prevent movement of pipe and protect adjacent piping or equipment. Make necessary taps in piping prior to testing.
   b. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
   c. New Piping Connected to Existing Piping: Isolate new piping with pipe plugs, valves, or other means as approved by Engineer.
   d. Test section may be filled with water and allowed to stand under low pressure prior to testing.
3. Procedure:
   a. Maximum filling velocity shall not exceed 0.25 feet per second, calculated based on full area of pipe.
   b. Expel air from piping system during filling.
   c. Test pressure shall be 10 psi above system operating pressure.
   d. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
   e. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding additional make-up water only as necessary to restore test pressure.
   f. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
4. Allowable Leakage: Measured leakage shall not exceed 2 gallons per inch of diameter per mile of pipe per 2 hours.
5. Joint Test: Perform as follows:
   a. Joint Test Device:
      1) Provide device specifically designed for testing of pipe joints, and consisting of a metal cylinder, seal ring on each side of joint, and method of applying pressure to joint.
      2) Manufacturers:
         a) Mechanical Research and Design Corporation, Sebastian, FL.
         b) Cherne Industries, Minneapolis, MN.
   b. Minimum pressure, test duration, and allowable leakage shall be in accordance with ASTM C1103.

END OF SECTION

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SECTION 33 05 01.09
POLYVINYL CHLORIDE (PVC) PRESSURE PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C110, Ductile-Iron and Gray-Iron Fittings.
   b. C153, Ductile-Iron Compact Fittings, for Water Service.
   c. C605, Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
   d. C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Distribution.
   e. C905, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 Inches through 48 Inches (350 mm through 1,200 mm) for Water Transmission and Distribution.
   f. C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Distribution.
2. ASTM International (ASTM):
   a. D2241, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
   b. D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   c. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   d. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   e. D2672, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
   f. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
   g. D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
3. NSF International (NSF).

1.02 SUBMITTALS

A. Action Submittals: Drawings showing pipe diameter, pipe class, and fitting details.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Hydrostatic Testing Plan: Submit at least 15 days prior to testing and at minimum, include the following:
    a. Testing dates.
    b. Piping systems and section(s) to be tested.
    c. Method of isolation.
    d. Method of conveying water from source to system being tested.
    e. Calculation of maximum allowable leakage for piping section(s) to be tested.
3. Certification of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
4. Test report documentation.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Solvent Cement: Store in accordance with ASTM D2855.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe:

1. PVC, conforming to requirements of AWWA C905.
2. SDR shall be as shown on Drawings.
3. Pipe to be used for potable water conveyance shall be manufactured from National Sanitation Foundation (NSF) approved compounds.

B. Joints:

1. Rubber gasketed.
2. Conform to AWWA C905.

C. Fittings: Ductile iron, conforming to AWWA C153 or AWWA C110.

D. Service Saddles:

1. Double strap type with minimum strap width of 2 inches.
2. Straps shall be Type 304 stainless steel. Saddles shall be ductile iron, epoxy-coated, 10 mils minimum thickness.
3. Minimum Pressure Rating: 200 psi.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with AWWA C605.

B. Solvent cement used for joints as recommended by pipe manufacturer.

C. Joints:

1. Rubber Gasketed: In accordance with manufacturer's written instructions.
2. Solvent Cemented: In accordance with ASTM D2855.
3. Restrained Joint Systems: In accordance with manufacturer's written instructions.

D. Pipe Bending for Horizontal or Vertical Curves:

1. Bending of pipe barrels larger than 12 inches in diameter is not allowed.
2. Radius of curves shall not exceed 75 percent of manufacturer's recommended values.
3. Use blocks or braces at pipe joints to ensure axial deflection in gasketed or mechanical joints does not exceed allowable deflection.

E. Maximum Joint Deflection at Mechanical Joint: 75 percent of manufacturer's recommended values.

3.02 INSPECTION AND HYDROSTATIC TESTING

A. General:

1. Notify Engineer in writing at least 5 days in advance of testing. Perform testing in presence of Engineer.
2. Using water as test medium, all newly installed pipelines shall successfully pass hydrostatic leakage test prior to acceptance.
3. Conduct field hydrostatic test on buried piping after trench has been completely backfilled and compacted. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.

4. Contractor may, if field conditions permit and as approved by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial informal service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
5. Supply of Temporary Water: In accordance with Section 01 50 00, Temporary Facilities and Controls.
6. Dispose of water used in testing.
7. Install temporary thrust blocking or other restraint as necessary to prevent movement of pipe and protect adjacent piping or equipment. Make necessary taps in piping prior to testing.
8. Wait a minimum of 5 days after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
9. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
10. New Piping Connected to Existing Piping:
    a. Isolate new piping with grooved-end pipe caps, blind flanges, or other means as acceptable to Engineer.
    b. Provide appropriate thrust blocking.

B. Hydrostatic Testing Procedure:

1. Furnish testing equipment, as approved by Engineer, which provides observable and accurate measurements of leakage under specified conditions.
2. Maximum Filling Velocity: 0.25 foot per second calculated based on full area of pipe.
3. Expel air from piping system during filling.
4. Test Pressure: 100 psi above system operating pressure, but in no case less than 250 psi.
5. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
6. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding make-up water only as necessary to restore test pressure to within 5 psi of specified hydrostatic test pressure.
7. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

C. Maximum Allowable Leakage:

$$L = \frac{ND(P)^{1/2}}{7400}$$

where:

L = Allowable leakage, in gallons per hour.
N = Number of joints in tested line.
D = Nominal diameter of pipe, in inches.
P = Average test pressure during leakage test, in pounds per square inch.

END OF SECTION

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SECTION 33 05 01.12
GRAVITY SEWER PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C105, Polyethylene Encasement for Ductile Iron Pipe Systems.
   b. C110, Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in. (75 mm Through 1200 mm), for Water.
   c. C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger - Shop Applied.
   e. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
   f. C302, Reinforced Concrete Pressure Pipe, Noncylinder Type.
   g. C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in. (100 mm Through 300 mm), for Water Distribution.
2. ASTM International (ASTM):
   a. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   b. A746, Standard Specification for Ductile Iron Gravity Sewer Pipe.
   c. C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
   d. C150, Standard Specification for Portland Cement.
   e. C151, Ductile-Iron Pipe, Centrifugally Cast, for Water.
   f. C361, Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
   g. C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
   h. C443, Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
   i. C596, Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
   j. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
   k. D16, Standard Terminology for Paint, Related Coatings, Materials, and Applications.
   l. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

m. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
n. D2241, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
o. D2412, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
p. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
q. D3212, Standard Specification for Joints For Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
r. E329, Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
s. F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
t. F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

1.02 DEFINITIONS

A. CCTV: Closed Circuit Television.

B. SDR: Standard Dimension Ratio.

1.03 SUBMITTALS

A. Action Submittals:

1. Information on gasket polymer properties.
2. Tee fabrication details.
3. Application methods, application requirements, and chemical resistance data for coating and lining products.
4. Fabrication plans and calculations for reinforced concrete pipe, fittings, and joint details. Include concrete mix design, reinforcement dimensions, concrete cover, spacing, and placement tolerances to be used.
5. Quick setting grout design mix.

B. Informational Submittals:

1. Certificates:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, that products furnished meet requirements of this section.

   b. Certification of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
   c. Certified statement from manufacturer of gaskets, setting forth that basic polymer used in gaskets and test results of physical properties of compound are in accordance with ASTM F477 for PVC pipe or AWWA C111 for ductile iron pipe.
2. Manufacturer's Written In-Plant Quality Control Program: Quality control procedures and materials testing to be used throughout manufacturing process. Submit prior to manufacture of any pipe for this Project.
3. Test or historical performance data to verify that joint design meets requirements of these specifications.
4. Provide pipe and pipe joint test results with delivery of pipe. Do not deliver pipe not meeting test requirements to Project Site.
5. Manufacturer's written recommendations for pipe handling and installation.
6. Field Leakage Testing Plan: Submit at least 15 days in advance of the testing and include at least the following:
   a. Testing dates.
   b. Piping systems and sections to be tested.
   c. Test type.
   d. Method of isolation.
   e. Method of conveying water from source to system being tested.
   f. Calculation of maximum allowable leakage for piping section(s) to be tested.
   g. Method for disposal of test water, if applicable.
7. CCTV Inspection Equipment: Submit minimum 15 days prior to performing inspections:
   a. Name and qualifications of inspection firm.
   b. Brand name and model number of video equipment to be used.
8. Leakage test results.
9. PVC pipe deflection test results.
10. CCTV inspection videotapes and inspection logs. Videotapes shall become property of Owner.

PART 2 PRODUCTS

2.01 POLYVINYL CHLORIDE PIPE (PVC)

A. 15-Inch Diameter and Smaller:

1. In accordance with ASTM D3034.
2. Joints: Integral bell and spigot, in accordance with ASTM D3212.

3. Minimum SDR: 26.
4. Cell Classification: 12454-B or 12454-C, as defined by ASTM D1784.
5. Fittings: SDR 35 minimum wall thickness.
6. Gaskets: Factory fabricated rubber compression type with solid cross section in accordance with ASTM F477. Lubricant for joining pipe as approved by pipe manufacturer.

B. 18-Inch through 36-Inch Diameter:

1. In accordance with ASTM F679.
2. Joints: Integral bell and spigot, in accordance with ASTM D3212.
3. Minimum Pipe Stiffness: 46 psi when tested in accordance with ASTM D2412.
4. Cell Classification: Minimum 12454-C, as defined by ASTM D1784.
5. Fittings: Wall thickness no less than wall thickness of equivalent size of pipe.
6. Gaskets: Factory fabricated rubber compression type with solid cross section conforming to ASTM F477.

2.02 DUCTILE IRON PIPE (DIP)

A. Pipe:

1. Conform to ASTM A746.
2. Thickness Class: 51.
3. Joints: Push-on with rubber gaskets conforming to AWWA C111. Lubricant for joining pipe as approved by pipe manufacturer.
4. Fittings: Ductile iron conforming to AWWA C110, lined and coated same as pipe.

B. Lining:

1. Ceramic Epoxy:
   a. 40-mil nominal lining consisting of ceramic particle-reinforced novolac epoxy, such as Protecto 401 by the Vulcan Group with installation by U.S. Pipe.
   b. Line interior of bell and exterior of spigot in joint sealing areas with 6 to 10 mils of specified lining.
   c. Surface Preparation: SP10 near-white abrasive blast.
   d. Pinhole Detection: 2,500 volts minimum over 100 percent of lined surfaces.

C. Polyethylene Wrap and Tape for Ductile Iron Pipe:

1. Polyethylene Wrap: 8 mils, minimum thickness, conforming to AWWA C105.

2. Adhesive Tape: Thermoplastic pressure sensitive; minimum thickness of 8 mils; minimum width of 1 inch.

2.03 SERVICE CONNECTION PIPE AND FITTINGS

A. Acceptable Pipe Materials: Ductile iron.

B. Use one type of service connection pipe material throughout, no interchanging of pipe and fittings allowed. Long-radius bends shall be used for changes in direction, unless approved otherwise by Engineer.

C. Size shall be as shown on Drawings.

2.04 PIPE FOR WATERLINE CROSSINGS

A. PVC pressure pipe conforming to AWWA C900 or ASTM D2241; SDR 26, maximum.

B. Class 51 ductile iron pipe conforming to AWWA C151.

2.05 PIPE TO MANHOLE CONNECTOR

A. Manufacturers and Products:

1. Uniseal, Evansville, Indiana; Pipeconx, Universal Pipe Connector.
2. NPC Inc., Milford, NH; Kor-N-Seal.

2.06 FLEXIBLE COMPRESSION COLLAR

A. Mechanical joint coupling with No. 305 stainless steel bands.

B. Manufacturers:

1. Calder, Inc. , Bellflower, CA.
2. Fernco Inc., Davison, MI.

2.07 CONCRETE

A. Compressive Strength: Minimum 2,500 psi at 28 days.

2.08 JOINT CEMENT MORTAR

A. Mixture: 1 part cement and 2 parts of clean sand well graded of such size that will pass No. 8 sieve.

B. Combine cement and sand in proper proportions and thoroughly mix with water.

C. Quantity of water used in preparation of mortar shall be minimum required to produce mixture sufficiently workable for purpose intended.

D. No admixtures shall be used, unless otherwise specified or acceptable to Engineer.

2.09 QUICK SETTING GROUT

A. High strength, nonstaining grout.

B. Reach initial set within 90 minutes at 70 degrees F and minimum compressive strength of 2,500 psi within 24 hours.

C. Shrinkage shall be less than 0.01 percent when tested in accordance with ASTM C596.

PART 3 EXECUTION

3.01 EXAMINATION

A. Notify Engineer immediately of manufacturing imperfections or damage caused by improper handling.

B. Verify size, pipe condition, and pipe class prior to installation of pipe.

C. Repairs to RCP pipe section will be allowed, only if approved in writing by Engineer. Damaged pipe which, in opinion of Engineer, cannot be repaired, will be rejected and removed from the Project Site.

3.02 PREPARATION

A. Pipe Distribution: Do not distribute more than 1 week's supply of materials in advance of laying, unless otherwise approved by Engineer.

B. Inspect pipe and fittings prior to lowering into trench to ensure no cracked, broken, or otherwise defective materials are being used.

C. Remove foreign matter and dirt from inside of pipe and fittings and keep clean during and after laying. Wash ends of section clean with wet brush prior to joining sections of pipe.

3.03 INSTALLATION

A. General:

1. Install pipe sections in accordance with manufacturer's recommendations.

2. Provide and use proper implements, tools, and facilities for safe and proper prosecution of Work.
3. Lower pipe, fittings, and appurtenances into trench, piece by piece, by means of crane, slings, or other suitable tools and equipment, in such a manner as to prevent damage to pipe materials, protective coatings and linings. Do not drop or dump pipe into trenches.

B. Line and Grade:

1. Establish line and grade for pipe by use of lasers.
2. Measure for grade at pipe invert, not at top of pipe.
3. Do not deviate from line or grade, as shown on Drawings, more than1/2 inch, provided that such variation does not result in a level or reverse sloping invert.

C. Laying and Jointing:

1. Use gasket lubricant as recommended by gasket manufacturer.
2. Lay pipe upgrade with bell ends pointing in direction of laying.
3. When field cutting or machining pipe is necessary, use only tools and methods recommended by pipe manufacturer and approved by Engineer.
4. After section of pipe has been placed in its approximate position for jointing, clean end of pipe to be joined, inside of joint, and rubber ring immediately before joining pipe.
5. Assemble joint in accordance with recommendations of manufacturer.
6. Apply sufficient pressure in making joint to assure that joint is "home" as defined in standard installation instructions provided by pipe manufacturer. Inside joint space shall not exceed 50 percent of pipe manufacturer's recommended maximum allowance.
7. Place pipe to specified line and grade to form smooth flow line.
8. Ensure that bottom of pipe is in contact with bottom of trench for full length of each section.
9. Check for alignment and grade after joint has been made.
10. Place sufficient pipe bedding material to secure pipe from movement before next joint is installed.
11. When pipe is laid within movable trench shield, take precautions to prevent pipe joints from pulling apart when moving shield ahead.
12. When laying operations are not in progress, and at close of day's work close and block open end of last laid section of pipe to prevent entry of foreign material or creep of gasketed joints.
13. Take precautions to prevent "uplift" or floating of line prior to completion of backfill operation.

14. Connections between one pipe material and another shall be by means of flexible compression collar, installed in accordance with the manufacture's recommendations, or concrete closure collar.

D. Connection to Structure or Manhole:

1. Locate standard pipe joint within 1.5 feet of outside face of structure for pipe 18 inches and smaller and within one pipe diameter for pipe 21 inches and larger.
2. Plug or close off pipe stubbed with watertight plug.
3. Connect PVC pipe to manhole with pipe to manhole connector in accordance with manufacturer's recommendations.

E. Crossing Waterlines: Where sewer crosses less than 18 inches below waterline, use ductile iron or PVC pressure pipe for crossing or encase in concrete envelope for a minimum distance of 9 feet on each side of waterline.

F. Ductile Iron Pipe:

1. Cutting and Dressing of Ductile Iron Pipe Ends:
   a. Cut at right angles to centerline of pipe to leave smooth end, without damage to pipe.
   b. Use only approved mechanical cutter.
   c. Taper cut end of pipe to be used with rubber gasket joints by grinding or filing 1/8 inch back at an angle of approximately 30 degrees with centerline of pipe.
   d. Remove sharp or rough edges.
   e. Abrade cut ends with grinding wheel and apply lining repair material. Use only compatible repair materials provided by pipe lining manufacturer. Allow repair lining to harden and cure before installation.
2. Polyethylene Wrap:
   a. Before installing wrap, clean pipe exterior of foreign material.
   b. Cut wrap approximately 2 feet longer than pipe section.
   c. Overlap wrap approximately 1 foot; seal joints with adhesive tape.
   d. Tape entire circumference of pipe at 3-foot intervals along pipe.
   e. Repair rips, punctures, or other damage to polyethylene with adhesive tape.
   f. When fittings cannot be practically wrapped in a tube, use a flat sheet or split tube of polyethylene. Securely tape seams.

3.04 SERVICE CONNECTION TEES

A. Install as shown on Drawings.

B. Install caps or plugs on tees.

C. Furnish tee outlets with gasketed type joint or approved adapter to join service connection pipe.

D. Concrete encase tees in trenches deeper than 12 feet. Do not encase joints at ends of tee fitting.

3.05 SERVICE CONNECTION INSTALLATION

A. In general, service connections shall extend to street or alley right-of-way line or easement line, or as directed by Engineer.

B. Minimum Slope: 1/4 inch per foot.

C. Minimum Trench Depth: 4 feet at property line or on private property within permanent sewer easement. Engineer will determine required depth at end of line in each case.

D. Progress of Construction: Unless otherwise approved by Engineer, install service connection not more than 5 days after backfilling of sewer trench in block or equivalent 400-foot section of sewer.

E. Laying and Jointing of Service Connection Pipe and Fittings:

1. Maximum deflection permissible with any one fitting shall not exceed 45 degrees and shall be accomplished with long-radius curves or bends. Short-radius elbows or curves will not be permitted, except by permission of Engineer.
2. Make service connection to sewer system at manhole when directed by Engineer. Where service connection pipe is connected to manhole or concrete structure, make connection so standard pipe joint is located not more than 1.5 feet from structure.
3. Provide end of service connection line and fittings with standard watertight plug, cap, and stopper, suitably braced to prevent blow-off during hydrostatic or air testing.

F. First length of pipe out from tee on lateral or main shall not be greater than 3 feet in length.

3.06 CLEANING

A. Clean each section of completed sewer pipeline prior to testing.

B. Place screen or dam in downstream manhole of section being cleaned to catch debris.

C. Remove material from each manhole section before cleaning the next section downstream.

D. Method: High velocity hydro-cleaning equipment or hand sweeping.

E. Dispose of cleaning water in a manner that will not damage or interfere with adjacent property and in a manner acceptable with Engineer and regulatory agencies.

3.07 GASKET FIELD SPLICE TESTS

A. Perform field splice test on 20 percent of each lot of delivered gaskets, in accordance with ASTM C361 in presence of Engineer.

B. Furnish feeler gauges of proper size, type, and shape to verify proper placement of gasket.

C. Test section of gasket shall be at point where ends of gasket are joined together.

D. If gasket joints separate during test, entire lot will be rejected and shall immediately be removed from Site.

3.08 HYDROSTATIC AND PNEUMATIC TESTS

A. General:

1. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.
2. Pipe 18 inches in diameter and smaller shall be tested for leakage using Hydrostatic Exfiltration or Pneumatic Test Methods at Contractor's option.
3. Pipe over 18 inches in diameter shall be tested for leakage using Hydrostatic Exfiltration Test Method.
4. Individual joints may be tested on pipe 36 inches in diameter and larger at Contractor's option.
5. Pipe shall successfully pass leakage test prior to acceptance
6. Test sections of constructed sewer between stations only after service connections, manholes, and backfilling are completed. Testing may be done prior to placement of asphaltic concrete or roadway structural section.
7. Isolate new pipelines that are connected to existing pipelines. Install pipe plugs as required to allow section of new pipe to be pressure tested.

8. Plug wyes, tees, stubs, and service connections with gasketed caps or plugs securely fastened or blocked to withstand internal test pressure. Such plugs or caps shall be removable, and their removal shall provide socket suitable for making flexible jointed lateral connection or extension.
9. Furnish testing equipment and perform tests as approved by Engineer. Testing equipment shall provide observable and accurate measurement of leakage under specified conditions.
10. Supply of temporary water shall be as stated in Section 01 50 00, Temporary Facilities and Controls.
11. Dispose of water used in testing.
12. Conduct initial leakage test after five sections of pipe have been installed to confirm integrity of pipe and joints.
13. Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial service leak test. Hydrostatic acceptance test shall not be conducted until backfilling has been completed.
14. Test sections of constructed sewer between stations only after service connections, manholes, and backfilling are completed. Testing may be done prior to placement of asphaltic concrete or roadway structural section.

B. Hydrostatic Exfiltration Test:

1. Fill pipe test section 24 hours prior to time of testing, if desired, to permit normal absorption into VCP and RCP pipe walls.
2. Procedure:
    a. Maximum filling velocity shall not exceed 0.25 foot per second, calculated based on full area of pipe.
    b. Expel air from piping system during filling.
    c. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
    d. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding additional make-up water only as necessary to restore test pressure.
    e. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
3. Measurement Accuracy: Plus or minus 1/8 gallon of water leakage under specified conditions
4. PVC and ductile iron pipe and joints shall sustain maximum water loss limit of 0.8 gallon per inch diameter per 1,000 feet of pipe, including service connections within test section per 2 hours. Allowable leakage shall be modified as stated below if hydrostatic head is other than 6 feet.

5. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested, but no less than 6 feet above inside top of highest section of pipe in test section, including service connections.
   b. In every case, determine height of water table at time of test by exploratory holes or such other methods approved by Engineer. Engineer will make final decision regarding test height for water in pipe section being tested.
   c. If hydrostatic head is other than 6 feet, allowable leakage as computed by criteria above shall be adjusted by the square root of actual head divided by square root of 6.
6. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 16 feet of water column. In no case shall length be greater than 700 feet or distance between manholes when greater than 700 feet.
7. Dispose of test water in a manner that will not damage or interfere with adjacent property and in a manner acceptable with Engineer and regulatory agencies.

C. Pneumatic Testing for 18-inch and Smaller Diameter Pipe:

1. Equipment:
   a. Calibrate gauges with standardized test gauge provided by Contractor at start of each testing day
   b. Install compressor, air piping manifolds, gauges, and valves at ground surface.
   c. Provide pressure release device, such as rupture disc or pressure relief valve, to relieve pressure at 6 psi or less.
   d. Restrain plugs used to close sewer lines to prevent blowoff.
2. Procedure:
   a. No person shall enter manhole or structure, or occupy area above opening of manhole or structure where pipe is under pressure.
   b. Determine height of groundwater table at time of test.
   c. Slowly introduce air into pipe section until internal air pressure reaches 4 psi greater than average backpressure of groundwater submerging pipe.
   d. Allow 2 minutes minimum for air temperature to stabilize.
   e. Allowable leakage for sewers constructed of air-permeable materials, such a concrete or clay:
      1) When pressure is decreased to 3.5 psig, air pressure test shall begin.
      2) Test shall consist of measuring time in seconds for pressure in pipe to drop from 3.5 psig to 2.5 psig.

3) Pipe leakage shall be considered acceptable if time in seconds for pressure drop is equal to or greater than required time as calculated below:

$K = 0.0111d^2L$
$C = 0.000392dL$

If C_t is less than or equal to 1.0, then time = K_t
If C_t is between 1.0 and 1.75, then time = K_t/C_t
If C_t is greater than or equal to 1.75, then time = $K_t/1.75$

Where: d = pipe diameter in inches
L = pipe length in feet
K = value for each length of pipe of a specific diameter
C = value for each length of pipe of a specific diameter
K_t = Sum of all K values
C_t = Sum of all C values

f. This method is based on allowable air loss rate of 0.003 cubic foot per minute (cfm) per square foot of internal pipe surface, with total air loss rate not less than 2.0 cfm nor greater than 3.5 cfm.

g. Allowable leakage for sewers constructed of nonair-permeable materials such as ductile iron, and polyvinyl chloride (PVC).
   1) When nonair-permeable pipe is subjected to low pressure air test, time in seconds for pressure drop shall be equal to or greater than three times required time calculated using procedure above.
   2) Defective Piping Sections: Replace or test and seal individual joints and retest as specified.

D. Hydrostatic Joint Testing:

1. If pipe fails to pass hydrostatic test and location of leak cannot be readily identified, individual joint tests shall be performed. After leaking joints have been located and repaired, retest pipeline. As alternative to filling entire pipe and measuring leakage, test each individual joint for leakage.
2. Testing shall be performed prior to installing PVC liner patch at joints.
3. Provide device specifically designed for testing of pipe joints and consisting of a metal cylinder, seal ring on each side of joint, and method of applying pressure to joint.
   a. Manufacturer:
      1) Mechanical Research and Design, Inc., Manitowoc, WI.
      2) Cherne Industries, Inc., Minneapolis, MN.

4. Measurement Accuracy: Plus or minus 0.05 gallon of water leakage under specified conditions.
5. Determine height of groundwater table at time of test.
6. Minimum Pressure, Each Joint: 2.5 psi above backpressure of groundwater.
7. Minimum Test Duration, Each Joint:
    a. 20 minutes for 60-inch diameter pipe and smaller.
    b. 10 minutes for pipe larger than 60-inch diameter.
8. Maximum Leakage: Leakage per joint shall not exceed maximum water loss limit of 0.0008 gallon per hour per inch-diameter times length of distance between pipe joints.

E. Test Report Documentation:

1. Test date.
2. Pipe section or pipe joint tested.
3. Test Method.
4. Test Pressure.
5. Length of test.
6. Pressure or water loss.
7. Remarks, including:
    a. Leaks (type, location).
    b. Repair/ replacement performed to remedy excessive leakage.
8. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

F. Subsequent Failure: Visible infiltration of groundwater following successful test shall be considered evidence that original test was in error or that subsequent failure of pipeline has occurred.

G. PVC Pipe Deflection Test:

1. General:
    a. Test installed pipeline for deflection by pulling a mandrel through sewer without aid of mechanical pulling device.
    b. Perform test at least 10 days after trench backfill and compaction have been completed.
2. Mandrel:
    a. Full circle, solid or rigid odd number of legs (minimum 9 legs) steel cylinder with pulling rings at each end.
    b. Diameter: Sized to allow only as much initial deflection for ultimate deflection of 5 percent.
    c. Obtain Engineer approval, through Contractor calculations, for use of mandrel smaller than 96-2/3 percent of inside diameter of pipe.

3. Correcting Deficiencies or Obstructions:
   a. Excavate to springline of pipeline and replace and recompact pipe zone material.
   b. Internal pipe rerounding or vibration will not be allowed.
   c. If pipe does not pass mandrel test after replacement of pipe zone material and trench backfill, re-excavate and replace pipeline.

3.09 INSPECTION

A. Television Pipeline Inspection:

1. General:
   a. Internally inspect sewer pipelines by closed circuit television (CCTV) after completion of pipeline cleaning and testing.
   b. Conduct inspection in presence of Engineer or Project Representative.
2. Procedure:
   a. Provide complete and continuous taped record and written log of inspection.
   b. Format: VHS, T-120 videotape, color. Do not use long-play as quality is not acceptable
   c. Television Camera Equipment:
      1) Rotating lens or pan and tilt.
      2) Resolution: Minimum 350 lines per inch.
      3) Focal Distance: Adjustable through a range of 6 inches to infinity.
      4) Remote-Reading Footage Counter: Accurate to less than 1 percent error.
      5) Lighting: Sufficient to provide clear, in-focus picture of entire inside periphery of pipe, and minimizes reflection.
   d. Pull camera at uniform rate, stopping to properly document defects. Maximum pull of camera shall not exceed 30 feet per minute.
3. Quality Standard:
   a. Provide clear, sharp image when played back on conventional television receiver.
   b. Neatly label videotape showing contents, project title, tape number, pipe structure identification numbers, date tape was made, and inspection company.
   c. Tapes to include:
      1) Opening Screen:
         a) Date of inspection.
         b) Pipe structure identification number.
         c) Upstream and downstream node identification numbers.

d) Street address.
e) Pipe size.
f) Normal (upstream to downstream) or reverse (downstream to upstream) pull.

2) Continuous View: Current distance along reach (tape counter footage).

B. Deficiencies Requiring Correction:

a. Variations in alignment greater than specified herein.
b. Joint separations greater than allowed by pipe manufacturer.
c. Visible infiltration.
d. Presence of debris or foreign objects.
e. Obvious damage or defects in pipeline.

END OF SECTION

SECTION 33 05 13
MANHOLES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
    a. A36, Standard Specification for Carbon Structural Steel.
    b. A48, Standard Specification for Gray Iron Castings.
    c. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
    d. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
    e. A240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
    f. A536, Standard Specification for Ductile Iron Castings.
    g. A615/A615M, Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement.
    h. B139, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
    i. C14, Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
    j. C387, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
    k. C443, Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
    l. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
    m. C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
    n. D4101, Standard Specification for Propylene Plastic Injection and Extrusion Materials.
    o. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
    p. F594, Standard Specification for Stainless Steel Nuts.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Cast-in-Place Manholes: Details of construction.
   b. Precast Manholes: Details of construction.
   c. Precast Base, Cones, and Top Slab Sections: Details of construction.
   d. Manholes Over Existing Piping: Plans and schedule for diverting flow.

B. Informational Submittals:

1. Proposed curing method for cast-in-place concrete structures.
2. Precast Manhole Sections: Manufacturer's results of tests performed on representative sections to be furnished.
3. Certified load test data for precast manhole steps.
4. Plan for diversion of flow during installation of manhole over existing piping.

PART 2 PRODUCTS

2.01 PRECAST MANHOLES

A. Riser Sections:

1. Minimum 48 inches in diameter.
2. Fabricate in accordance with ASTM C478.
3. Minimum Wall Thickness: 4 inches or 1/12 times inside diameter, whichever is greater.
4. Top and bottom shall be parallel.
5. Joints: Confined O-ring with rubber gaskets meeting ASTM C443.

B. Cone Sections:

1. Provide eccentric cones.
2. Same wall thickness and reinforcement as riser section.
3. Top and bottom shall be parallel.

C. Base Sections and Base Slab:

1. Base Sections: Base slab integral with sidewalls.
2. Fabricate in accordance with ASTM C478.

D. Manhole Extensions:

1. Concrete grade rings; maximum 6 inches high.
2. Fabricate in accordance with ASTM C478.

E. Preformed Plastic Gasket – Acceptable Manufacturers:

1. Hamilton Kent of Nevada, Sparks, NV.
2. Henry Company, Houston, TX.

F. Polypropylene Steps:

1. Fabricate from minimum 1/2 inch, Grade 60, steel bar meeting ASTM A615/A615M.
2. Polypropylene encasement shall conform to ASTM D4101.
3. Minimum Width: 13 inches, center-to-center of legs.
4. Embedment: 3-1/2-inch minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.
5. Cast in manhole sections by manufacturer.
6. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.

G. Source Quality Control:

1. All test specimens shall be mat tested and meet permeability test requirements of ASTM C14.
2. Conduct tests at point of manufacture prior to delivery of any section.
3. Sections to be tested will be selected at random from stockpiled material to be supplied for the Project.

2.02 CAST-IN-PLACE MANHOLES

A. Reinforcing Steel: Furnish as specified in Section 03 21 00, Reinforcing Steel.

B. Concrete: Furnish as specified in Section 03 30 00, Cast-in-Place Concrete.

2.03 MANHOLE FRAMES AND COVER

A. Castings:

1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
2. Cast Iron: ASTM A48 Class 30B.
3. Ductile Iron: ASTM A536, Grade 60-40-12.
4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. Cover: True and seat within ring at all points with the word SEWER in 2-inch raised letters.

2.04 WATERTIGHT FRAME FASTENERS

A. Galvanize after fabrication in conformance with ASTM A123.

2.05 MANHOLE FRAME TO STRUCTURE SEALS

A. Gasket:

1. Extrude or mold from a high-grade rubber compound.
2. Comply with material test requirements of ASTM C923.
3. Minimum Thickness: 3/16 inch.
4. Minimum Unstretched Length: Sufficient to extend from the manhole frame, across a maximum of 12 inches of extension rings, to the manhole cone section.
5. Fabricate bands for compressing sleeve against manhole from Type 304 stainless steel:
   a. Channeled Sheet: Minimum 16-gauge, ASTM A167.
   b. Round: 5/16-inch diameter, ASTM A240.

B. Screws, Bolts, or Nuts: Stainless steel conforming to ASTM F593 and ASTM 594, Type 304.

C. Internal gasket or its appurtenances shall not extend into the manhole opening to restrict entry into or exit from the manhole.

D. Gasket shall be made only of materials that have been proven to be resistant to the following exposures and conditions:

1. Sanitary sewage.
2. Corrosion or rotting under wet or dry conditions.
3. Gaseous environment in sanitary sewers and at road surfaces including common levels of ozone, carbon monoxide, and other trace gases at the sites of installation.
4. Biological environment in soils and sanitary sewers.
5. Chemical attack by road salts, road oil, and common street spillages or solvents used in street construction or maintenance.
6. Temperature ranges, variations, and gradients in the area of construction.
7. Variations in moisture conditions and humidity.
8. Fatigue failure caused by a minimum of 30 freeze-thaw cycles per year.
9. Vibrations due to traffic loading.

10. Fatigue failure due to repeated variations of tensile, compressive and shear stresses, and repeated elongation and compression.
11. Any combination of the above.

E. Materials used shall be compatible with each other and with manhole materials.

F. Design gasket to meet the following requirements:

1. Continuously prevent leakage of water from outside the manhole into the manhole at the joints between the manhole frame and the cone section.
2. Seal shall remain flexible, allowing repeated vertical movements of frame from 0 to 2 inches or repeated horizontal movements of frame with respect to top of extension or cone from 0 to 1/2 inch due to pavement movements or other causes, or both types of movement occurring simultaneously at rates not exceeding 1/10 inch per minute.

2.06 MORTAR

A. Standard premixed in accordance with ASTM C387, or proportion one part portland cement to two parts clean, well-graded sand that will pass a 1/8-inch screen.

B. Admixtures: May be included but do not exceed the following percentages of weight of cement:

1. Hydrated Lime: 10 percent.
2. Diatomaceous Earth or Other Inert Material: 5 percent.

C. Mix Consistency:

1. Tongue-and-Groove Type Joint: Such that mortar will readily adhere to pipe.
2. Confined Groove (Keylock) Joint: Such that excess mortar will be forced out of groove and support is not provided for section being placed.

2.07 CLEANOUT FRAMES AND COVERS

A. Castings:

1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
2. Cast Iron: ASTM A48, Class 30B.
3. Ductile Iron: ASTM A536, Grade 65-40-12.

4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. Covers: True and seat within frame at all points.

2.08 IMPORTED PIPE BASE

A. Furnish as specified in Section 31 23 23.15, Trench Backfill.

2.09 MANHOLE MARKER POSTS

A. Size and Type: 4 inches by 4 inches by 8 feet, S4S, cedar, pine, redwood, or fir, Construction Grade or better.

B. Prime top (exposed) 3 feet 8 inches, followed by two coats of safety orange enamel.

1. Primer: Tnemec; Series 36 Undercoater.
2. Enamel: Tnemec; Series 2H Tnemec Gloss.

C. Bottom (Buried) Portion:

1. Treat bottom 4 feet 4 inches with a solution consisting of 5 percent by weight of pentachlorophenol dissolved with a petroleum solvent.
2. At Contractor's option, entire post may be treated provided 30 days elapse prior to painting.

D. Lettering:

1. Stencil the letters on all sides of each post.
2. Letters to be black enamel, 2 inches high.

2.10 FLEXIBLE JOINTS

A. Manufacturers:

1. "Kor-N-Seal" flexible rubber boot with stainless steel accessories as manufactured by NPC, Inc., Milford, New Hampshire.
2. "Z-LOK XP" or "A-LOK" flexible connectors as manufactured by A-LOK Products, Inc., Tullytown, PA.

PART 3 EXECUTION

3.01 GENERAL

A. Remove and keep all water clear from the excavation during construction and testing operations.

B. Place imported pipe base material on undisturbed earth; thoroughly compact with a mechanical vibrating or power tamper.

3.02 EXCAVATION AND BACKFILL

A. Excavation: As specified in Section 31 23 16, Excavation.

B. Backfill: As specified in Section 31 23 23.15, Trench Backfill.

3.03 INSTALLATION OF PRECAST MANHOLES

A. Concrete Base:

1. Cast-in-Place:
    a. Vibrate to densify concrete and screed so first precast manhole section to be placed has a level, uniform bearing for full circumference.
    b. Deposit sufficient mortar on base to assure watertight seal between base and manhole wall, or place first precast section of manhole in concrete base before concrete has set. Properly locate and plumb first section.
2. Precast:
    a. Place on compacted imported base material.
    b. Properly locate, ensure firm bearing throughout, and plumb first section.

B. Sections:

1. Carefully inspect precast manhole sections to be joined.
2. Thoroughly clean ends of sections to be joined.
3. Do not use sections with chips or cracks in the tongue.
4. Locate precast steps in line with each other to provide a continuous vertical ladder.

C. Mortar Joints:

1. Thoroughly wet joint with water prior to placing mortar.
2. Place mortar on groove of lower section prior to section installation.
3. Fill joint completely with mortar of proper consistency.
4. Trowel interior and exterior surfaces smooth on standard tongue-and-groove joints.
5. Prevent mortar from drying out and cure by applying an approved curing compound or comparable approved method.
6. Do not use mortar mixed for longer than 30 minutes.
7. Chip out and replace cracked or defective mortar.

8. Completed Manholes: Rigid and watertight.

D. Preformed Plastic Gaskets (In lieu of mortar joints):

1. Use only pipe primer furnished by gasket manufacturer.
2. Install gasket material in accordance with manufacturer's instructions.
3. Completed Manholes shall be rigid and watertight.

E. Rubber Gasketed Joints: Install in accordance with manufacturer's instructions.

F. Extensions:

1. Provide on manholes in streets or other locations where a subsequent change in existing grade may be likely.
2. Install to height not exceeding 12 inches.
3. Lay grade rings in mortar with sides plumb and tops level.
4. Seal joints with mortar as specified for sections, and make watertight.

3.04 MANHOLE INVERT

A. Construct with smooth transitions to ensure an unobstructed flow through manhole. Remove sharp edges or rough sections that tend to obstruct flow.

B. Where full section of pipe is laid through manhole, break out top section as shown and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.

3.05 CAST-IN-PLACE MANHOLE

A. Reinforcing Steel: Install as specified in Section 03 21 00, Reinforcing Steel.

B. Concrete: Install as specified in Section 03 30 00, Cast-in-Place Concrete.

C. Steps:

1. Install manhole steps at 16 inches on center, plus or minus 1/4-inch tolerance, and locate to provide a continuous vertical ladder.
2. Do not vary spacing between any two adjacent steps by more than 1/2 inch.
3. The distance between wall of manhole and center of rung, measured at the point of embedment, shall be not less than 4 inches or more than 6-1/4 inches.

3.06 MANHOLE FRAMES AND COVERS

A. Set frames in bed of mortar with mortar carried over flange as shown.

B. Set tops of covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

C. At locations shown, install **[A: exterior]** **[B: interior]** manhole frame to structure seals in accordance with manufacturer's instructions.

3.07 MANHOLE PIPING

A. Drop Assembly:

1. Extend pipe from the drop to a minimum of 3 feet beyond the manhole excavation into the trench, and connect to sewer pipe with an adapter.
2. Support lower drop elbow with concrete monolithically-placed with manhole base.

B. Flexible Joints:

1. Provide in pipe not more than 1-1/2 feet from manhole walls.
2. Where last joint of pipe is between 1-1/2 and 6 feet from manhole wall, provide flexible joint in manhole wall.

C. Stubouts for Future Connections:

1. Provide same type and class of pipe as specified for use in service connection, lateral, main, or trunk sewer construction. Where there are two different classes of pipe at manhole use higher strength pipe.
2. Grout pipe in precast walls or manhole base to provide watertight seal or use flexible joints as specified herein.
3. Maximum Length: 1-1/2 feet outside manhole wall.
4. Construct invert channels as shown. Unless otherwise approved by Engineer, match inside top elevation of service connection pipe to inside top elevation of outlet pipe.
5. Test Plugs:
   a. Install rubber-gasketed plugs in end of stubouts with gasket joints similar to sewer pipe being used.
   b. Plugs shall withstand internal or external pressures without leakage.
   c. Adequately brace plugs against all hydrostatic or air test pressures.

D. Permanent Plugs: Clean interior contact surfaces of pipes to be cut off or abandoned as shown, and construct plug as follows:

1. Pipe 18 Inches or Less in Diameter: Concrete plug in end, minimum 8 inches in length.
2. Pipe 21 Inches and Larger:
   a. Construct plugs of common brick, concrete block, or concrete.
   b. Plaster exposed face of block or brick plugs with mortar.
3. Plugs shall be watertight and capable of withstanding internal and external pressures without leakage.

3.08 MANHOLES OVER EXISTING PIPING

A. Maintain flow through existing pipelines at all times.

B. Plastic Pipe:

1. Use solvent recommended by pipe manufacturer to slightly soften the pipe wall.
2. Apply a dense coating of clean mortar sand over all areas that will be in contact with concrete.
3. Allow mortar to dry completely prior to placing concrete.

C. Concrete Pipe: Apply a bonding agent on all surfaces to be in contact with concrete.

D. Construct base under existing piping.

E. Construct manhole as specified.

F. Break out existing pipe within new manhole, cover edges with mortar, and trowel smooth.

G. Protect new concrete and mortar work for 7 days after placing concrete.

3.09 CONNECTIONS TO EXISTING MANHOLES

A. Break out existing manhole bases or grouting as necessary.

B. Clean all surfaces and apply a bonding agent.

C. Regrout to provide smooth flow into and through manholes.

D. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.10 FIELD QUALITY CONTROL

A. Hydrostatic Testing:

1. When, in Engineer's opinion, groundwater table is too low to permit visual detection of infiltration leaks, hydrostatically test up to 20 percent but in no case less than 10 percent of the total manholes.
2. Procedure: Plug inlets and outlets and fill manhole with water to height determined by Engineer.
3. A manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into the pipe walls to take place.
4. Leakage in each manhole shall not exceed 0.1 gallon per hour per foot of head above the invert.
5. Repair manholes that do not meet the leakage test, or do not meet specified requirements from visual inspection.
6. If more than 25 percent of the manholes tested fail the hydrostatic test, test all or as many manholes as Engineer deems necessary.

B. Testing Cast-in-Place Manhole Steps:

1. Test each step for a horizontal pullout load of 400 pounds with the load applied over a width of 3-1/2 inches and centered on the rung.
2. Apply the load at a uniform rate until the required test load is reached.
3. Provide suitable hydraulic jacks and gauges to perform the test.
4. Steps will be considered acceptable if they remain solidly embedded after application of test load and if no cracking or fracture of the step nor spalling of the concrete, masonry, or mortar is evident.
5. Replace, or reset and retest, steps failing to withstand required load.

END OF SECTION

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SECTION 33 12 16
AIR AND VACUUM RELEASE VALVE ASSEMBLIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B36.10M, Welded and Seamless Wrought Steel Pipe.
   c. B36.19M, Stainless Steel Pipe.
   d. Boiler and Pressure Vessel Code.
2. American Water Works Association (AWWA):
   a. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   b. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
   c. C220, Stainless Steel Pipe, 4 In. (100 mm) and Larger.
   d. C500, Metal-Seated Gate Valves for Water Supply Service.
   e. C504, Rubber-Seated Butterfly Valves.
   f. C507, Ball Valves, 6 In. Through 48 In. (150 mm Through 1200 mm)
   g. C509, Resilient-Seated Gate Valves for Water Supply Service.
   h. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
   i. C550, Protective Interior Coatings for Valves and Hydrants.
   j. C800, Underground Service Line Valves and Fittings.
3. ASTM International (ASTM):
   a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   b. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
   c. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   d. D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
4. Environmental Protection Agency (EPA): Safe Drinking Water Act.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data sheets for make and model.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Maximum recommended test pressure; maximum and minimum recommended working pressures of air valves, isolation valves, flanges, connecting piping, and fittings.
4. Recommended seating materials for specified operating pressures.

B. Informational Submittals:

1. Manufacturers' Instructions:
   a. Installation and testing of products specified.
   b. Pipeline tapping and service saddle installation.
2. Operation and maintenance data.
3. Affidavit of Compliance in accordance with AWWA C512 stating valve and all materials used conform to applicable requirements of AWWA C512 and these Specifications, and tests specified have been performed and all requirements have been met.
4. Affidavit of Compliance that materials comply with the requirements of the EPA Safe Drinking Water Act and other federal, state, and local requirements.

PART 2 PRODUCTS

2.01 AIR VALVES

A. General:

1. Air release, air/vacuum, and combination air valves shall conform to AWWA C512.
2. Exterior of air valves shall be coated in accordance with Section 09 90 00, Painting and Coating.
3. Interior of air valves shall be coated in accordance with AWWA C550.
4. Air valves shall be factory tested in accordance with AWWA C512, except test pressure shall be increased from 150 percent of working pressure to 200 percent of working pressure.
5. Suitable for operating pressures between 1 and 150 psi.

B. Air and Vacuum Valve, Water Service, 1/2 Inch to 16 Inches:

1. Suitable for water service.

2. Automatically exhausts air during system filling and allows air to re-enter during draining or when vacuum occurs.
3. Air/water Inlet: NPT.
4. Air Outlet: NPT.
5. Rated 150 psi working pressure, cast iron, ductile iron, or steel body, cover with stainless steel float and trim.
6. Manufacturers and Products:
    a. APCO Valve and Primer Corp.; Series 140 or 150.
    b. Val-Matic Valve; Series 100.

C. Air Release Valve, Water Service, 1/2 Inch to 6 Inches:

1. Suitable for water service, automatically exhausts small amounts of entrained air under pressure that accumulates in a system.
2. Air/water Inlet: NPT.
3. Air Outlet: NPT.
4. Rated 150 psi working pressure; cast iron, ductile iron, or steel body, cover with stainless steel float and trim.
5. Orifice diameter 1/2 inches.
6. Manufacturers and Products:
    a. APCO Valve and Primer Corp.; Model 200.
    b. Val-Matic Valve; Model 45.5.
7. All air release valves comply with this paragraph unless Drawings specifically call for different model and/or orifice size.

D. Combination Air Valve, Water Service, 1 Inch to 16 Inches:

1. Suitable for water service.
2. Combines operating features of air and vacuum valve, and air release valve.
    a. Air and vacuum portion to automatically exhaust air during filling of system and allow air to re-enter during draining or when vacuum occurs.
    b. Air release portion to automatically exhaust entrained air that accumulates in system.
3. Single body or dual body
4. Air/water Inlet: NPT.
5. Air Outlet: NPT.
6. Rated 150 psi working pressure; cast iron, ductile iron, or steel body, cover with stainless steel float and trim.
7. Manufacturers and Products:
    a. APCO Valve and Primer Corp.; Series 145C.
    b. Val-Matic Valve; Series 202C.2.

2.02 CONNECTION TO MAINLINE

A. Flanged Outlet or Fitting: Flange shall be Class 125 or as shown.

B. Service Saddle Tap:

1. Stainless steel double straps.
2. Body: Ductile iron, nylon, or epoxy coated.
3. Bolts and Nuts: Type 304 stainless steel.
4. Comply with applicable portions of AWWA C800.
5. Manufacturers and Products:
   a. Mueller; Series DR2S.
   b. Romac; Style 202S or 202N.

2.03 ISOLATION VALVES

A. Globe Valve 2 Inches and Smaller:

1. All-bronze, screwed ends, union bonnet, inside screw, rising stem.
2. Rated for minimum pressure of 150 psi.

B. Corporation Stop:

1. AWWA C800 type, with ends suitable for adjoining pipe.
2. Rated for minimum pressure of 150 psi.

C. Butterfly Valve:

1. AWWA C504, flanged ends.
2. Rated for minimum pressure of150 psi.
3. Provide lever operator.

D. Ball Valve:

1. AWWA C507, flanged ends.
2. Rated for minimum pressure of 150 psi.
3. Provide lever operator.

E. Ball Valve:

1. Threaded ends.
2. Rated for minimum pressure of 150 psi.
3. Provide lever operator.

2.04 PIPING BETWEEN AIR VALVE AND MAIN

A. Brass pipe conforming to ASTM B43.

PART 3 EXECUTION

3.01 INSTALLATION

A. Valves:

1. In accordance with manufacturer's printed instructions.
2. Orient valve with easy access to operator.
3. Replace valves that drip or do not function properly.

B. Pipe Support: Install in accordance with details as shown on Drawings and according to Section 40 05 15, Piping Support Systems.

3.02 TESTING AND INSPECTION

A. Air Valve:

1. May be either tested while testing pipelines, or as a separate step.
2. Isolation valves shall be in open position during pipeline test.

B. Isolation Valves: Test that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other.

C. Air and Vacuum Valves: Inspect valves as pipe is being filled to verify venting and seating is fully functional.

D. Verify leak-free performance during testing.

3.03 SUPPLEMENT

A. The supplement listed below, following "End of Section," are part of this Specification.

1. Air and Vacuum Release Valves Schedule and Legend.

END OF SECTION

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AIR AND VACUUM RELEASE VALVES SCHEDULE									
Tag No.	**Location**	**Valve Type**	**Size (inches)**	**Flowstream**	**Inlet Pressure (psi)**	**Outlet Pressure (psi)**	**Max. Oper. Press. (psi)**	**Max. Oper. Flow (gpm)**	**Notes**
FT-GBS-ARV-001	GAC contactor backwash supply header	ARV	2	GBS	30	0	35	10,600	30" mainline size
FT-GBS-ARV-002	GAC contactor backwash supply header	ARV	2	GBS	30	0	35	10,600	30" mainline size
FT-GBS-ARV-003	GAC contactor backwash supply header	ARV	2	GBS	30	0	35	10,600	30" mainline size
FT-FBS-ARV-001	Filter backwash supply header at AT building	ARV	2	FBS	30	0	35	11,200	30" mainline size
AT-FBS-ARV-002	Filter backwash supply header at entrance to filter building	ARV	2	FBS	30	0	35	11,200	20" mainline size
FT-WS-ARV-001	EQ Pump 1 Discharge	ARV	2	WS	30	0	35	3,500	24" mainline size
FT-WS-ARV-002	EQ Pump 2 Discharge	ARV	2	WS	30	0	35	3,500	24" mainline size
FT-WS-ARV-003	EQ Pump Discharge	ARV	2	WS	30	0	35	7,000	24" mainline size
FT-SWS-ARV-001	Slurry Water Pump 1 discharge	ARV	2	SWS	130	0	160	120	4" mainline size
FT-SWS-ARV-002	Slurry Water Pump 2 discharge	ARV	2	SWS	130	0	160	120	4" mainline size
FT-GE-ARV-001	GAC contactor 1 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size

AIR AND VACUUM RELEASE VALVES SCHEDULE									
Tag No.	**Location**	**Valve Type**	**Size (inches)**	**Flowstream**	**Inlet Pressure (psi)**	**Outlet Pressure (psi)**	**Max. Oper. Press. (psi)**	**Max. Oper. Flow (gpm)**	**Notes**
FT-GE-ARV-002	GAC contactor 2 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-GE-ARV-003	GAC contactor 3 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-GE-ARV-004	GAC contactor 4 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-GE-ARV-005	GAC contactor 5 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-GE-ARV-006	GAC contactor 6 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-GE-ARV-007	GAC contactor 7 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-GE-ARV-008	GAC contactor 8 effluent	ARV	2	GE	25	0	30	4,000	20" mainline size
FT-UE-ARV-001	combined UV effluent to clearwell no. 2	ARV	2	UE	15	0	20	24,500	36" mainline size
FT-FE-ARV-001	south filters combined effluent to GAC pump station well	ARV	2	FE	5	0	10	15,300	36" mainline size
FT-FE-ARV-002	north filters combined effluent to GAC pump station well	ARV	2	FE	5	0	10	15,300	36" mainline size

VALVE TAG LEGEND FOR AIR VALVE SCHEDULE

VALVE TAG FORMAT:

#1	#2	#3	#4
MP	GI	ARV	001

#1 - PLANT CODE

FT	FORT THOMAS
MP	MEMORIAL PARKWAY

#2 - FLOWSTREAM CODE

AS	AIR SCOUR
ASV	AIR SCOUR VENT
BWW	BACKWASH WASTE
BYP	BYPASS
BS	BACKWASH SUPPLY
CTW	CONTACTOR WASTE
CW	COOLING WATER
DR	DRAIN
FW	FINISHED WATER
FBS	FILTER BACKWASH SUPPLY
FE	FILTER EFFLUENT
SF	SLURRY FEED
GBS	GAC BACKWASH SUPPLY
GE	GAC EFFLUENT
GI	GAC INFLUENT
OF	OVERFLOW
SPD	SUMP PUMP DISCHARGE
SWS	SLURRY WATER SUPPLY
UE	UV EFFLUENT
WS	WASTE

#3 - VALVE TYPE

ARV	AIR RELEASE VALVE
AVV	AIR/VACUUM VALVE
CAV	COMBINATION AIR VALVE

#4 - UNIQUE VALVE NUMBER

-001, -002, ETC

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SECTION 33 12 19
WATER UTILITY DISTRIBUTION FIRE HYDRANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C502, Dry-Barrel Fire Hydrants.
   b. C600, Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances.
2. ASTM International (ASTM): C94, Standard Specification for Ready-Mixed Concrete.

1.02 SUBMITTALS

A. Action Submittals: Catalog cuts of system components.

B. Informational Submittal: Certificate of Compliance: Upon completion of the system installation, verify all fire department hose connections, and check all fire safety devices to ensure their readiness for emergency connection and operation.

PART 2 PRODUCTS

A. Fire hydrants shall conform to AWWA C502. Hydrants shall conform to the standards of the Northern Kentucky Water Service District and as shown on the plans. All fire hydrants shall have auxiliary valves for isolating water flow to the hydrant. All fire hydrants and auxiliary valves shall be positively locked to the water main by restrained joints, hydrant adapters, or other approved method.

B. Hydrants shall be designed to 200 psi working pressure and shall be shop tested to 300 psi hydrostatic pressure with the main valve both open and closed. The barrel shall have a breakable safety section and/or base bolts just above the ground line. Hydrants shall have a main valve opening of 5 1/4 inches, a 6 inch mechanical joint inlet to be suitable for setting in a trench 3' 6" deep minimum, and shall be the traffic style hydrant so that the main valve remains closed when the barrel is broken off. Hydrants shall have a dry top and shall be self draining, when the main valve is closed. Self draining hydrants shall drain to dry wells provided exclusively for that purpose. Hydrant drains shall not be connected to storm or sanitary sewers. Hydrants located generally in the Covington System and other areas determined by the

District (flood zones) shall have all drain holes plugged prior to installation. Hydrants shall be rotatable in a minimum of eight (8) position in 360 degrees. All hydrants shall have two (2)- two and one half (2 1/2) inch hose nozzles and one (1) steamer or pumper connection threaded to conform to Northern Kentucky Water Service District Standards: steamer nozzle shall be National Standard Thread and 2 1/2" outlets shall be Northern Kentucky Water Service District Standard Thread (Old Cincinnati Thread). The operating nut and the nuts of the nozzle caps shall be square in shape, measuring one (1) inch from side to side. Hydrant body shall be painted yellow for areas designed for 150 psi working pressure and red for areas in excess of 150 psi. Hydrants used in areas in excess of 150 psi working pressure shall be designed to operate at the higher pressures and shall have independent operating valves on each 2 1/2" outlet.

C. All hydrants shall be right hand open, clockwise, except in certain areas of Campbell Co. as specified in Standard Drawings and shall have a direction arrow of operation cast into the dome of the hydrant. Installation per Standard Drawing #109.

2.02 FIRE HYDRANTS

A. Fire hydrants shall conform to AWWA C502. Hydrants shall conform to the standards of the Northern Kentucky Water Service District and as shown on the plans. All fire hydrants shall have auxiliary valves for isolating water flow to the hydrant. All fire hydrants and auxiliary valves shall be positively locked to the water main by restrained joints, hydrant adapters, or other approved method.

B. Hydrants shall be designed to 200 psi working pressure and shall be shop tested to 300 psi hydrostatic pressure with the main valve both open and closed. The barrel shall have a breakable safety section and/or base bolts just above the ground line.

C. Hydrants shall have a main valve opening of 5 1/4 inches, a 6 inch mechanical joint inlet to be suitable for setting in a trench 3' 6" deep minimum, and shall be the traffic style hydrant so that the main valve remains closed when the barrel is broken off. Hydrants shall have a dry top and shall be self draining, when the main valve is closed. Self draining hydrants shall drain to dry wells provided exclusively for that purpose. Hydrant drains shall not be connected to storm or sanitary sewers.

D. Hydrants located generally in the Covington System and other areas determined by the District (flood zones) shall have all drain holes plugged prior to installation. Hydrants shall be rotatable in a minimum of eight (8) position in 360 degrees.

E. All hydrants shall have two (2)- two and one half (2 1/2) inch hose nozzles and one (1) steamer or pumper connection threaded to conform to Northern Kentucky Water Service District Standards: steamer nozzle shall be National Standard Thread and 2 1/2" outlets shall be Northern Kentucky Water Service District Standard Thread (Old Cincinnati Thread). The operating nut and the nuts of the nozzle caps shall be square in shape, measuring one (1) inch from side to side.

F. Hydrant body shall be painted yellow for areas designed for 150 psi working pressure and red for areas in excess of 150 psi. Hydrants used in areas in excess of 150 psi working pressure shall be designed to operate at the higher pressures and shall have independent operating valves on each 2 1/2" outlet

G. All hydrants shall be right hand open, clockwise, except in certain areas of Campbell Co. as specified in Standard Drawings and shall have a direction arrow of operation cast into the dome of the hydrant. Installation per Standard Drawing #109.

2.03 PRECAST CONCRETE PIER BLOCK

A. Nominal dimensions of 8-inch thickness by 16-inch square base.

B. Compressive Strength: 3,000 psi at 28 days.

2.04 GRAVEL FOR DRAINAGE

A. Washed 3/4-inch crushed rock or graded river gravel. Free of organic matter, sand, loam, clay, and other small particles that will restrict water flow through gravel.

2.05 FOUNDATION STABILIZATION MATERIAL

A. Furnish when existing trench material or imported pipe base material will not support soft or flooded spots in excavated trench.

B. Maximum 3-inch hard rock free from excessive clay material, but enough fines to bind larger fragments.

2.06 CONCRETE FOR THRUST BLOCKING

A. Ready-mix meeting ASTM C94, Alternative 2.

B. Compressive Strength: 2,500 psi at 28 days.

C. Aggregate Size: 1-1/2 inches.

D. Slump: 2 to 4 inches.

2.07 THRUST TIES

A. 3/4-inch diameter steel rods.

B. Duc-Lugs Manufacturer: The Stellar Corp., Columbus, OH.

PART 3 EXECUTION

3.01 GENERAL

A. Install hydrants in accordance with Sections 3.7 and 3.8 of AWWA C600, unless specified otherwise.

3.02 EXCAVATION

A. Excavate to subgrade. Fill over excavated areas with foundation stabilization material. Tamp to provide firm foundation.

3.03 BASE BLOCK

A. Place on firm, level subgrade to ensure uniform support.

3.04 INSTALLATION OF HYDRANTS

A. Locate hydrants to provide accessibility and to minimize potential damage from vehicles.

1. Relocate improperly set hydrants.
2. Hydrant Located behind Curbs: Set barrel so pumper nozzle or hose nozzle caps are a minimum of 18 inches from gutter face of curb.
3. Hydrant Located in Space between Curb and Sidewalk: Not less than 8 inches, clear from sidewalks.
4. Hydrant Located between Sidewalk and Property Line: Minimum clearance 8 inches from sidewalk.
5. Set hydrants so safety flange is a minimum of 2 inches above finished ground or sidewalk level.

B. Place hydrant on base block carefully to prevent the base block from breaking.

C. Joints shall conform to Section 3.4 of AWWA C600 when cast or ductile iron pipe is used.

D. Maintain hydrant in a plumb position during subsequent Work.

3.05 GRAVEL FOR DRAINAGE

A. Place gravel around base block and hydrant bottom in accordance with Section 3.7 of AWWA C600.

3.06 CONCRETE THRUST BLOCKING

A. Place blocking after hydrant is set in final position and join to pipe.

B. Concrete thrust block shall have a minimum of 4 square feet of bearing area against undisturbed earth.

3.07 THRUST TIES

A. Install thrust ties in lieu of concrete thrust blocking when ground surface behind hydrant is less than 2 feet above top of hydrant base.

END OF SECTION

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SECTION 33 13 00
DISINFECTING OF WATER UTILITY DISTRIBUTION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. B300, Hypochlorites.
   b. B301, Liquid Chlorine.
   c. B302, Ammonium Sulfate
   d. B303, Sodium Chlorite.
   e. C651, Disinfecting Water Mains.
   f. C652, Disinfection of Water Storage Facilities.
   g. C653, Disinfection of Water Treatment Plants.
2. Standard Methods for the Examination of Water and Wastewater, as published by American Public Health Association, American Water Works Association, and the Water Environment Federation.

1.02 SUBMITTALS

A. Action Submittals: Submit detailed procedure(s), plans, schedule, and sequence for the cleaning, disinfection, and testing of the project components for approval a minimum of 30 days before beginning the disinfection process.

B. Informational Submittals:

1. Plan describing and illustrating conformance to appropriate AWWA standards and this Specification.
2. Proposed locations within system where Samples will be taken.
3. Type of disinfecting solution and method of preparation.
4. Certification that employees working with concentrated chlorine solutions or gas have received appropriate safety training.
5. Method of disposal for highly chlorinated disinfecting water.

PART 2 PRODUCTS

2.01 WATER FOR DISINFECTION AND TESTING

A. Clean, uncontaminated, and potable.

B. Owner will supply potable quality water. Contractor shall convey in disinfected pipelines or containers

2.02 CONTRACTOR'S EQUIPMENT

A. Furnish chemicals and equipment, such as pumps and hoses, to accomplish disinfection.

B. Water used to fill pipeline may be supplied using a temporary connection to existing distribution system. Provide protection against cross-connections as required by AWWA C651. If the Contractor selects this option, temporary connection shall be provided by the Contractor at no additional cost to the Owner.

2.03 DISINFECTANT

A. The disinfectant product(s) shall be chlorine solutions in accordance with the applicable AWWA standard.

PART 3 EXECUTION

3.01 GENERAL

A. Conform to AWWAC651 for pipes and pipelines, C652 for tanks and reservoirs, and C653 for water treatment plants, filters, and GAC contactors, except as modified in these Specifications.

B. Disinfect the following items installed or modified under this Project, intended to hold, transport, or otherwise contact potable water:

1. Pumps.
2. Tanks, including the GAC Pump Well.
3. Filters and GAC Contactors.
4. Pipelines: Disinfect all new pipelines installed as a part of this project including piping that connect existing filters to the GAC facilities, GAC facilities to the UV facilities, and UV facilities to existing piping and clearwell(s) or distribution system, including all bypass piping, backwash piping from pumps to filters or contactors, all GAC feed piping, and all appurtenances.
5. Slurry water pumps, piping, and appurtenances.
6. Existing filter effluent flumes after completion of bulkhead construction and pipe connections.
7. All concrete flow channels in the GAC facilities, flow splitting structures and all other piping and facilities which convey or are in contact with the water between the existing filters and the existing clearwells shall be disinfected.
8. The existing filter effluent flumes(s) after bulkhead construction and pipe connections are complete.

9. The existing clearwell inlet box after demolition, bulkhead construction, and installation of the new GAC effluent piping are complete.
10. Disinfect surfaces of materials that will contact finished water, both during and following construction, using one of the methods described in AWWA C652 and C653. Disinfect prior to contact with finished water. Take care to avoid recontamination following disinfection.
11. The EQ Tanks, Pumps, and discharge piping do not require disinfection.

C. Prior to application of disinfectants, clean pumps, tanks contactors, channels, and pipelines of loose and suspended material.

D. The Contractor shall remove all debris and thoroughly clean existing clearwell #1 in accordance with the procedures contained in AWWA 653 after the demolition and construction of the proposed modifications to the clearwell inlet box. The Owner will perform the disinfection for clearwell #1.

E. Allow freshwater and disinfectant solution to flow into pipe or vessel at a measured rate so chlorine-water solution is at specified strength. Do not place concentrated liquid commercial disinfectant in pipeline or other facilities to be disinfected before it is filled with water.

3.02 SEQUENCING AND SCHEDULING

A. Commence disinfection after completion of following:

1. Completion and acceptance of internal painting of system(s).
2. Hydrostatic and pneumatic testing, pressure testing, functional and performance testing and acceptance of pipelines, pumping systems, structures, and equipment.

B. The contractor shall submit detailed procedure(s), schedule, and sequence for the disinfection of the project components.

C. Disinfection shall be completed immediately prior to placing facilities into service.

3.03 PIPING AND PIPELINES

A. Cleaning:

1. Before disinfecting, clean all foreign matter from pipe in accordance with AWWA C651.

2. If the continuous feed method or the slug method of disinfection, as described in AWWA C651 are used, flush pipelines with potable water until clear of suspended solids and color. Provide hoses, temporary pipes, ditches, and other conduits as needed to dispose of flushing water without damage to adjacent properties.

B. Disinfecting Procedure: In accordance with AWWA C651, unless herein modified.

3.04 PUMPS

A. Disinfecting Solutions: Minimum free chlorine concentration of 100 ppm.

B. Application:

1. Inject disinfecting solution into pump and associated piping. Apply by spray or swab for areas not accessible by injection.
2. Operate valves and pump appurtenances during disinfection to ensure that disinfecting solution is dispersed into all parts of pump and lines.
3. Vertical pumps shall be installed in the pump wells and disinfected to the extent possible with the pump wells/tanks.
4. Submit disinfection procedures for approval prior to beginning the process. Procedures shall comply with the applicable AWWA standards in all respects.
5. After chlorination, flush water from pump until water through the unit is chemically and bacteriologically equal to permanent source of supply.

3.05 TANKS AND RESERVOIRS

A. Cleaning:

1. Clean interior surfaces using water under pressure before sterilizing. Isolate tank from system to prevent contaminating materials from entering the distribution system. Cleaning shall:
   a. Remove all deposits of foreign nature.
   b. Remove all biological growths.
   c. Clean the slopes, walls, top, and bottom.
   d. Avoid damage to the structure.
   e. Avoid pollution or oil deposits by workers and equipment.
2. Dispose of water used in cleaning in accordance with applicable regulations before adding disinfecting solution to tank.

B. Disinfecting Procedure: In accordance with AWWA C652, unless herein modified. Parts of structures, such as ceilings or overflows that cannot be immersed, shall be spray or brush disinfected.

3.06 CONTACTORS

A. Prior to disinfection, remove foreign material from contactor structures. Clean using fire hoses and tools suitable for adequate scrubbing and cleaning. Pump or drain scrub water from structures.

B. Disinfection Procedure: In accordance with AWWA C653, unless herein modified.

3.07 DISPOSAL OF HEAVILY CHLORINATED WATER

A. Do not allow flow into a waterway without neutralizing disinfectant residual.

B. See the appendix of AWWA C651, C652, and C653 for acceptable neutralization methods.

3.08 TESTING

A. Collection of Samples:

1. Coordinate activities to allow Samples to be taken in accordance with this Specification and the applicable AWWA standard.
2. Provide valves at sampling points.
3. Provide access to sampling points.

B. Test Equipment:

1. Clean containers and equipment used in sampling and make sure they are free of contamination.
2. Obtain sampling bottles with instructions for handling from Owner's laboratory.

C. Chlorine Concentration Sampling and Analysis:

1. Collect and analyze Samples in accordance with AWWA standards.

D. After tanks, reservoirs, contactors, pumps, channels, structures, and pipelines have been cleaned, disinfected, and refilled with potable water, Owner will take water Samples and have them analyzed for conformance to bacterial limitations for public drinking water supplies. Contractor shall provide assistance as requested in collection of the samples.

1. Samples shall be collected in accordance with applicable AWWA Standard.

2. Samples shall be analyzed for coliform concentrations in accordance with latest edition of Standard Methods for the Examination of Water and Wastewater.

E. If minimum Samples required above are bacterially positive, disinfecting procedures and bacteriological testing shall be repeated until bacterial limits are met.

END OF SECTION

SECTION 33 39 00
PRECAST CONCRETE UTILITY STRUCTURES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this standard:

1. American Association of State Highway and Transportation Officials AASHTO):
   a. Standard Specifications for Highway Bridges.
   b. Standard Specification for Transportation Materials and Methods of Sampling and Testing.
2. ACI International (ACI):
   a. ACI 211.1; Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
   b. ACI 211.2; Standard Practice for Selecting Proportions for Structural Lightweight Concrete.
   c. ACI 211.3; Guide for Selecting Proportions for No-Slump Concrete.
   d. ACI 304R; Guide for Measuring, Mixing, Transporting, and Placing Concrete.
   e. ACI 305R; Hot Weather Concreting.
   f. ACI 306R; Cold Weather Concreting.
   g. ACI 309R; Consolidation of Concrete.
   h. ACI 318 Building Code Requirements for Structural Concrete.
   i. ACI 350 Code Requirements for Environmental Engineering Concrete Structures and Commentary.
   j. ACI 517.2R; Accelerated Curing of Concrete at Atmospheric Pressure.
3. American Concrete Pipe Association (ACPA):
   a. ACPA Concrete Pipe Handbook.
   b. ACPA Design Manual.
4. ASTM International (ASTM):
   a. ASTM A 36; Specification for Carbon Structural Steel.
   b. ASTM A 82; Specification for Steel Wire, Plain, for Concrete Reinforcement.
   c. ASTM A 184; Specification for Fabricated Deformed Steel Mats for Concrete Reinforcement.
   d. ASTM A 185; Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   e. ASTM A 496; Specification for Steel Wire, Deformed, for Concrete Reinforcement.

f. ASTM A 497; Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
g. ASTM A 615; Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
h. ASTM A 706; Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
i. ASTM A 775; Specification for Epoxy-Coated Reinforcing Steel Bars.
j. ASTM A 884; Specification for Epoxy-Coated Steel and Welded Wire Fabric for Reinforcement.
k. ASTM C 31; Standard Practice for Making and Curing Concrete Test Specimens in the Field.
l. ASTM C 33; Specification for Concrete Aggregates.
m. ASTM C 39; Test Method for Compressive Strength of Cylindrical Concrete Specimens.
n. ASTM C 94; Specification for Ready-Mixed Concrete.
o. ASTM C 125; Standard Terminology Relating to Concrete and Concrete Aggregates.
p. ASTM C 143; Test Method for Slump of Hydraulic Cement Concrete.
q. ASTM C 150; Specification for Portland Cement.
r. ASTM C 172; Standard Practice for Sampling Freshly Mixed Concrete.
s. ASTM C 173; Test Method for Air Content of Freshly Mixed Concrete by Volumetric Method.
t. ASTM C 231; Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
u. ASTM C 478; Specification for Precast Reinforced Concrete Manhole Sections.
v. ASTM C 494; Standard Specification for Chemical Admixtures for Concrete.
w. ASTM C 857; Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
x. ASTM C 858; Specification for Underground Precast Concrete Utility Structures.
y. ASTM C 877; Specification for External Sealing Bands for Concrete Pipe, Manholes and Precast Box Sections.
z. ASTM C 890; Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
aa. ASTM C 891; Practice for Installation of Underground Precast Concrete Utility Structures.
bb. ASTM C 913; Specification for Precast Concrete Water and Wastewater Structures.
cc. ASTM C 920; Specification for Elastomeric Joint Sealants.

dd. ASTM C 923; Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
ee. ASTM C 1037; Practice for Inspection of Underground Precast Concrete Utility Structures.

5. American Welding Society (AWS):
   a. AWS D 1.1 Structural Welding Code – Steel.
   b. AWS D 1.4Structural Welding Code - Reinforcing Steel.
6. Concrete Reinforcing Steel Institute (CRSI):
   a. Manual of Standard Practice.
   b. Placing Reinforcing Bars.
7. National Precast Concrete Association (NPCA): NPCA QC Manual Quality Control Manual for Precast Concrete Plants.
8. Precast/Prestressed Concrete Institute (PCI):
   a. MNL-120 PCI Design Handbook.
   b. MNL-122 Architectural Precast Concrete.

1.02 GENERAL REQUIREMENTS

A. Precast concrete units shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units similar to that indicated in the project specifications or drawings for at least ten (10) years.

1.03 SUBMITTALS

A. Preconstruction Submittals:

   1. Submit quality control procedures established by the precast manufacturer in accordance with the NPCA Quality Control Manual for Precast Concrete Plants.

B. Action Submittals:

   1. Drawings for Standard Precast Concrete Units:
      a. These drawings shall demonstrate that the applicable industry design standards have been met. Drawings shall include cut sheets showing conformance to project drawings and requirements and to applicable industry design standards listed in this specification. Detailed dimensions, installation and construction information shall be included on shop drawings. Details of steel reinforcement size and placement as well as supporting design calculations shall be included. Drawings shall indicate assumptions used in the design of standard units.

2. Drawings for Custom-Made Precast Concrete Units:
   a. These drawings shall show complete design, installation, and construction information in such detail as to enable the Engineer to determine the adequacy of the proposed units for the intended purpose. Details of steel reinforcement size and placement as well as supporting design calculations shall be included. The design drawings and calculations shall be prepared and sealed by a professional engineer registered in the Commonwealth of Kentucky.
3. Anchorage, Lifting Inserts and Devices:
   a. For anchors, lifting inserts and other devices, provide product data sheets and proper installation instructions upon request. The Precast concrete unit dimensions and safe working load shall be clearly indicated.
4. Accessory Items:
   a. For items including, but not limited to sealants, gaskets, pipe entry connectors, steps, racks and other items installed before or after delivery provide proper installation instructions and relevant product data.

C. Design Data:

1. Upon request, the precast concrete producer shall supply precast concrete unit design calculations and concrete mix design proportions and appropriate mix design test data. Structural design calculations shall be signed by a licensed professional engineer.

D. Test Reports:

1. Upon request, the precast concrete producer shall supply copies of material certifications and/or laboratory test reports, including mill tests and all other test data, for Portland cement, blended cement, pozzolans, ground granulated blast-furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.
2. Upon request, the precast concrete producer shall submit copies of test reports showing that the mix has been successfully tested to produce concrete with the properties specified and will be suitable for the project conditions. Such tests may include compressive strength, flexural strength, plastic or hardened air content, freeze-thaw durability, abrasion and absorption. Special tests for precast concrete items shall be clearly detailed in the specifications.
3. Upon request, the precast concrete producer will supply copies of in-plant QA/QC inspection reports.

E. Certificates

1. Submit quality control procedures established in accordance with NPCA Quality Control Manual for Precast Concrete Plants or verification of current NPCA Plant Certification.

1.04 DESIGN

A. Standard Precast Concrete Unit Design:

1. Design standard precast concrete units to withstand indicated design load conditions in accordance with applicable industry design standards [ACI 318, ACI 350, ASTM, ACPA Design Manual, PCI MNL-120, and AASHTO]. Design must also consider stresses induced during handling, shipping and installation in order to avoid product cracking or other handling damage. Design loads for precast concrete units shall be indicated on the shop drawings.

B. Non-Standard Precast Concrete Unit Design:

1. Design calculations and drawings of non-standard precast units shall be prepared and signed by a licensed professional engineer, and submitted for approval prior to fabrication. Design shall be in accordance with ASTM C 858 and other standards as applicable. Calculations shall include the analysis of units for lifting stresses and the sizing of lifting devices. The design shall include foundations considerations as noted in the geotechnical report for the project. A foundation or under drain system will not be installed for these structures. Design and installation shall prevent flotation of the structure at all times. All precast utility structures shall be watertight. Watertight joints, pipe-entry connectors and inserts should be used to ensure the integrity of the entire system. Structures shall be designed for H-20 Loading where indicated.

C. Joints and Sealants:

1. Joints and sealants between adjacent units shall be of the type and configuration indicated on shop drawings meeting specified design and performance requirements.

D. Concrete Mix Design:

1. Design in accordance with ASTM C 858 using Portland cement only, except as noted.
2. Concrete Compressive Strength: Precast concrete units shall have a 28-day compressive strength (f'c) of 5000 psi.

1.05 QUALITY ASSURANCE

A. NPCA Plant Certification:

1. The precast concrete producer shall be certified by the NPCA Plant Certification Program prior to and during production of the products for this project.

B. Qualifications, Quality Control and Inspection:

1. The precast concrete producer shall have been in the business of producing precast concrete units similar to those specified for a minimum of 10 years. The precast concrete producer shall maintain a permanent quality control department or retain an independent testing agency on a continuing basis. The agency shall issue a report, signed by a licensed professional engineer, detailing the ability of the precast concrete producer to produce quality units consistent with industry standards.

1.06 HANDLING, STORAGE AND DELIVERY

A. Handling:

1. Precast concrete units shall be handled and transported in a manner to minimize damage. Lifting devices or holes shall be consistent with industry standards. Lifting shall be accomplished with methods or devices intended for this purpose as indicated on shop drawings.

B. Storage:

1. Precast concrete units shall be stored in a manner that will minimize potential damage.

C. Delivery:

1. Precast concrete units shall be delivered to the site in accordance with the delivery schedule to avoid excessive build-up of units in storage at the site. Upon delivery to the jobsite all precast concrete units shall be inspected by the Engineer for quality and final acceptance.

PART 2 PRECAST CONCRETE UNITS

2.01 MANUFACTURERS

A. Underground Precast Concrete Utility Structures shall be manufactured by:

1. Hanson Pipe and Precast.

2. Sherman Dixie Concrete Products.
3. Approved Equal.

2.02 DIMENSIONS

A. Dimensions shall be as shown on the Drawings.

B. Sumps shall be provided as shown.

2.03 PIPE CONNECTIONS

A. All pipe connections to the structures shall be watertight. Submit proposed connection details for approval.

B. Acceptable water tight, flexible joints include:

a. Kor-N-Seal by NPC.
b. A-Lok by A-Lok Products.
c. Dura-Seal III by Dura-Tech.
d. Approved equal.

2.04 ACCESS HATCHES

A. Access hatch opening dimensions, location, and type as shown on Drawings.

B. Precast manufacturer shall provide access hatches as shown on the Contract Drawings in accordance with Section 05 50 00 Metal Fabrications.

2.05 ACCESSORIES

A. Ladders or manholes steps shall be provided for the structure as shown on the Drawings.

B. Provide sump pumps as required by Drawings.

C. Provide vents and other accessories as shown on the Drawings.

2.06 INSERTS AND EMBEDDED METAL

A. All items embedded in concrete shall be of the type required for the intended use and meet the following standards.

1. Structural Steel Plates, Angles, etc.: ASTM A 36.
2. Hot-Dipped Galvanized: ASTM A 152.

2.07 JOINT SEALANTS AND JOINT GASKETS

A. Rubber Gaskets for Circular Concrete Sewer Pipe and Culvert Pipe: ASTM C 443.

B. External Sealing Bands for Noncircular Sewer, Storm Drain and Culvert Pipe: ASTM C 877.

C. Preformed Flexible Joint Sealants for Concrete Pipe, Manholes, and Manufactured Box Sections: ASTM C 990.

D. Elastomeric Joint Sealants: ASTM C 920.

2.08 GROUT

A. Nonshrink Grout: ASTM C 1107.

B. Cementitious Grout: Shall be of suitable mix design for the intended use, consisting of Portland cement, sand, and water.

2.09 EMBEDDED ITEMS

A. Embedded items shall be positioned at locations specified in the design documents. Welding shall be performed in accordance with AWS D1.1 when necessary. Inserts, plates, weldments, lifting devices and other items to be embedded in precast concrete units shall be held rigidly in place so that they do not move significantly during casting operations.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation:

1. Precast concrete units shall be installed to the lines and grades shown in the contract documents or otherwise specified.
2. Prepare foundations and subgrade as shown on the Drawings.
3. Precast concrete units shall be lifted by suitable lifting devices at points provided by the precast concrete producer.
4. Precast concrete units shall be installed in accordance with applicable industry standards. The precast concrete producer shall provide any and all special installation instructions.
5. Field modifications to the product shall be completed by the precast manufacturer.

B. Watertightness:

1. All precast utility structures shall be watertight. Watertight joints, pipe-entry connectors and inserts should be used to ensure the integrity of the entire system.

3.02 FIELD QUALITY CONTROL

A. Job Site Tests:

1. Structures shall be visually tested for watertightness after the structure is installed and backfilling complete. All leaks shall be repaired, regardless of magnitude, to the satisfaction of the Engineer or the structure replaced.

END OF SECTION

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SECTION 33 44 13.13
CATCH BASINS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Welding Society (AWS): Code for Welding in Building Construction.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48, Standard Specification for Gray Iron Castings.
   c. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C387, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   f. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.

PART 2 PRODUCTS

2.01 CONCRETE

A. Concrete shall be ready-mixed, conforming to ASTM C94/C94M, Alternate 2. Compressive field strength shall be not less than 2,500 psi at 28 days. Maximum size of aggregate shall be 1-1/2 inch. Slump shall be between 2 and 4 inches. Field strength shall be assumed as equal to 85 percent of strength of laboratory-cured cylinders.

2.02 FORMS

A. Exposed surfaces shall be plywood. Others shall be steel, matched boards, plywood, or other acceptable material. Form vertical surfaces. Provide fillets on re-entrant angles. Trench walls, large rock, or earth will not be acceptable form material.

2.03 REINFORCING STEEL

A. Reinforcing steel shall conform to ASTM A615/A615M, Grade 60, deformed bars.

2.04 PRECAST UNITS

A. At the option of Contractor, approved precast units may be substituted for cast-in-place units. Precast units shall conform to ASTM C478 except dimensions shall be as shown. Concrete risers for extensions shall be a maximum of 6 inches high and of same quality as sections. Risers shall be reviewed by Engineer before installation.

2.05 MORTAR

A. Standard premixed mortar conforming to ASTM C387, Type S, or proportion 1 part portland cement to 2 parts clean, well-graded sand which will pass a 1/8-inch screen. Admixtures may be used not exceeding the following percentages of weight of cement: Hydrated lime, 10 percent; diatomaceous earth or other inert materials, 5 percent. Consistency of mortar shall be such that it will readily adhere to concrete.

2.06 FRAMES AND GRATES

A. Frames and grates for catch basins and storm drain inlets shall be fabricated of steel conforming to ASTM A36/A36M in accordance with details shown. Connections shall be welded. Welding shall conform to requirements of current Code For Welding in Building Construction of the American Welding Society. Frames and grates shall be properly cleaned and hot-dip galvanized after fabrication.

2.07 FRAMES AND GRATINGS

A. Cast iron frames and gratings for catch basins and storm drain inlets shall be as indicated. Bearing surfaces shall be clean and shall provide uniform contact. Castings shall be tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects, and shall conform to ASTM A48, Class 30.

PART 3 EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Excavate as required to accomplish construction. Backfill shall be as specified for adjoining pipe trench.

3.02 CONSTRUCTION OF CATCH BASINS AND INLETS

A. Construct inlets and catch basins at locations shown and in accordance with Drawings. Construct forms to dimensions and elevations required. Forms shall be tight and well braced. Chamfer corners of forms.

B. Prior to placing concrete, remove water and debris from forms. Moisten forms just prior to placing concrete. Handle concrete from transporting vehicle to forms in a continuous manner as rapidly as practical without segregation or loss of ingredients. Immediately after placing, compact concrete with mechanical vibrator. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

C. Screed top surface of exposed slabs and walls. When initial water has been absorbed, float surfaces with wood float and lightly trowel with steel trowel to smooth finish free from marks or irregularities. Finish exposed edges with steel edging tool. Remove forms and patch defects in concrete with mortar mixed in same proportions as original concrete mix.

D. Cure concrete by preventing loss of moisture for a period of 7 days. Accomplish with a membrane-forming curing compound. Apply curing compound immediately after removal of forms or finishing of slabs. Protect concrete from damage during 7-day curing period.

3.03 PLACING PRECAST UNITS

A. If material in bottom of trench is unsuitable for supporting unit, excavate and backfill to required grade with 3-inch minus, clean, pit-run material. Set units to grade at locations shown.

3.04 EXTENSIONS

A. Install extensions to height determined by Engineer. Lay risers in mortar with sides plumb and tops to grade. Joints shall be sealed with mortar, with interior and exterior troweled smooth. Prevent mortar from drying out and cure by applying a curing compound. Extensions shall be watertight.

3.05 INSTALLATION OF FRAMES AND GRATES

A. Set frames and grates at elevations indicated or as determined in field and in conformance with Drawings.

B. Frames may be cast in, or shall be set in mortar.

3.06 CLEANING

A. Upon completion, clean each structure of all silt, debris, and foreign matter.

END OF SECTION

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SECTION 33 46 00
SUBSURFACE DRAINAGE

PART 1 GENERAL

1.01 GENERAL

A. This section covers requirements for subsurface drainage piping, cleanouts, used to control shallow groundwater elevations within the Project area.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.
   b. M294, Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter.
2. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   c. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   d. D75, Standard Practice for Sampling Aggregates.
   e. D422, Standard Test Method for Particle-Size Analysis of Soils.
   f. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-µm) Sieve.
   g. F405, Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.
   h. F449, Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control.
   i. F667, Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.
3. Natural Resources Conservation Service (NRCS): Conservation Practice Standard 606, Subsurface Drain.

1.03 DEFINITIONS

A. Cleanouts: Surface access ports used to access drain lines and constructed of solid corrugated piping.

B. Drain Lines: Buried perforated pipe providing collection and conveyance of drain water from saturated soils to Drainage Management Unit (DMU).

C. Drainage Management Unit (DMU): An area drained by continuous connected network of drain lines discharging to a single pump station.

D. Granular Drain Material: Granular (sand or gravel) material used as an envelope around drain lines to provide pipe bedding, a permeable drainage zone, and stabilization of base soils to prevent migration of fines into drain lines.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Drain line pipe and fittings.
      2) Drain line installation equipment.
      3) High-pressure water jet cleaning equipment.
      4) Drain line sock; include manufacturer's recommendation for length of time UV-resistant sock may be left exposed.

B. Informational Submittals:

1. Granular Drain Material:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
   b. Test results from approved commercial testing laboratory before delivering material to Site and at least 10 days before material is required for use.
2. Surveys:
   a. Survey plan to collect drain line grade QA/QC information, including methods and schedule.
   b. Field Survey:
      1) Information consisting of stationing and ground surface elevation for each drain line prior to installation.
      2) Information consisting of stationing and installed invert elevation of drain pipe for drain line grade QA/QC.
3. Final drain line inspection and cleaning certification of compliance.

1.05 QUALITY ASSURANCE

A. Granular Drain Material Source:

1. Sampling:
   a. Conduct sampling of granular drain material source under supervision of Engineer in accordance with ASTM D75.
   b. Samples shall be representative and be clearly marked to show source of the material.
   c. Testing:
      1) In accordance with ASTM D1140 to determine percentage of fines.
      2) In accordance with ASTM D422 to determine gradation of particles larger than No. 200 sieve.
   d. Acceptance:
      1) Based on inspection of source by Engineer.
      2) Certified test results.
   e. Provide additional sampling, testing, and certification for every 500 cubic yards of material and when there is a change in granular drain material.
   f. Upon Engineer's request, supply supplemental samples of granular drain material to a testing laboratory designated by Owner during installation of drain lines. Owner will bear costs of testing.

1.06 DOCUMENTATION

A. Survey Plan:

1. Submit prior to beginning Work.
2. Update on a weekly basis through final drain line inspection and cleaning.

B. Surveying:

1. At least 10 days prior to installation, provide Engineer with the following information for each drain line:
   a. Field survey ground surface elevations at 250-foot increments.
   b. Calculated cut depth from ground surface to drain line invert elevation.
2. Provide surveyed drain line grades to Engineer no more than 5 days following installation of drain line section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Drain Sock:

1. Free of tears or other damage. Replace damaged sock.
2. Protect polyethylene drain lines with geotextile sock from UV light while stored onsite, unless geotextile sock is certified UV resistant.
3. UV-resistant Sock Stored Onsite Uncovered:
   a. Mark date of first sunlight exposure for each roll at factory.
   b. Do not allow UV-resistant sock to remain uncovered for more time than recommended by manufacturer.

PART 2 PRODUCTS

2.01 DRAIN LINES

A. Drain lines shall be perforated, unless otherwise noted on Drawings.

B. Perforated Drain Lines:

1. Heavy-duty corrugated polyethylene pipe meeting NRCS Conservation Practice Specification 606.
2. Conforming to ASTM F405 for 3-inch to 6-inch diameter pipe.
3. Conforming to ASTM F667 for 8-inch to 15-inch diameter pipe.
4. Water Inlet:
   a. Area of at least 1 square inch per foot of length.
   b. Dimensions of water inlet area shall be measured on a straight specimen with no external forces applied. Make measurements with instruments accurate to 0.01 inch.
   c. Perforations:
      1) Locate at least one perforation in the middle of corrugation so there is a shoulder on each side of perforation.
      2) Pipe 4 Inches to 12 Inches in Diameter:
         a) Slotted perforations shall be no wider than 1/8 inch or no longer than 1-1/4 inches.
         b) Slotted perforations equally spaced along length and circumference of tubing in not less than three rows.
      3) Pipe 15 inches in Diameter: Circular perforations will be accepted.

C. Nonperforated Drain Lines:

1. Heavy-duty corrugated polyethylene pipe with smooth interior walls.
2. Conforming to AASHTO M252 for 3-inch to 10-inch pipe.
3. Conforming to AASHTO M294 for 12-inch to 15-inch pipe, Type S.

D. Drain Sock:

1. Provide geotextile fabric material (sock) surrounding perforated drain lines. The manufacturer , type, opening size, fabric type and other relevant product information will be provided to the Engineer for approval prior to installation.

E. Drain Line Fittings:

1. Includes cleanouts, elbows, tees, branch connections, snap end caps, and reducing couplers.
2. Conforming to ASTM F405 and ASTM F667 as appropriate.
3. Cleanout snap end cap shall have a metal locating plate attached as shown in Drawings.
4. Diameter of cleanout fittings shall be as shown on Drawings.
5. Fittings installed as part of a continuous operation shall be clamp type rather than snap type. Fittings installed after pipe is in place may be either type.

2.02 GRANULAR DRAIN MATERIAL

A. In accordance with Section 31 23 23.15, Trench Backfill.

B. Composed of hard, durable, natural mineral particles free from organic matter, clay balls, soft particles, or other impurities or foreign matter.

2.03 TRENCH BACKFILL

A. Above pipe zone shall be in accordance with Section 31 23 23.15, Trench Backfill.

B. Within pipe zone shall be in accordance with Section 31 23 23.15, Trench Backfill.

C. Native backfill free from organic matter and other impurities or foreign matter and free from rocks larger than 3 inches in diameter.

2.04 BASE ROCK

A. In accordance with Section 31 23 23.15, Trench Backfill.

B. Base rock shall be clean 3/4-inch minus crushed granular or crushed rock uniformly graded from coarse to fine and with sufficient fines for proper compaction.

PART 3 EXECUTION

3.01 TRENCH EXCAVATION

A. Trenching Equipment:

1. Automatic laser-guided grade control.
2. Shoe (or boot) that allows granular fill to be placed uniformly around perforated drain lines in a continuous operation during installation.
3. Equipped with specially lengthened shield.
4. Capable of operating at sufficient speed to ensure drain lines can be laid and blinded with granular drain material before groundwater or soil-water slurry moves into trench and into direct contact with geotextile sock.

B. In accordance with Section 31 23 16, Excavation.

C. Excavate to lines and grades shown on Drawings allowing required thickness of granular fill to be placed around drain lines as shown on Drawings.

D. Installation of Drain Lines below Water Table: Install with trenching machine specifically designed for fluid soil conditions.

3.02 DRAIN LINE INSTALLATION

A. Pipe Installation:

1. Handle and install in conformance with ASTM F449.
2. Lay drain lines and appurtenances to lines and grades shown on Drawings.
3. Take special precautions on hot days to ensure stretch limit is not exceeded and excessive deflection is not caused by premature backfilling.

B. Fitting Installation:

1. Standard connections shall be in conformance with ASTM F449.
2. For nonstandard connections, join drain lines using manufacturer's printed recommended methods to complete connection.
3. Drain lines that are exposed to make a connection after trench backfilling shall have 4 inches of granular drain material replaced around drain line and connection.
4. Wrap connections and fittings with geotextile sock.

3.03 GRANULAR DRAIN MATERIAL INSTALLATION

A. Place granular drain material around perforated drain lines as shown on Drawings.

B. Place granular drain material around perforated drain lines in a continuous operation during placement of drain lines.

C. Place granular drain material with spreader boxes or other equipment in a manner to minimize segregation.

3.04 TRENCH BACKFILL

A. Trench shall not be left open overnight; plug end of drain lines and backfill trench to prevent animals, sediment, or debris from entering pipe.

B. Perform in a manner that shall minimize settlement.

C. Backfill may be placed automatically by trencher.

D. Where backfill material is placed in drain line trenches mechanically, backfill material shall be pushed onto slope of backfill previously placed and allowed to slide down into trench. Backfill shall not be pushed into trench in such a way as to permit free fall of material until at least 2 feet of cover has been provided over the top of drain line.

E. Place in such a manner to prevent displacement of drain line and granular fill after backfilling.

F. Trench Compaction:

1. After initial backfilling to final grade, a rubber-tired tractor shall be driven a minimum of two passes with tires running parallel on top of trench to facilitate compaction.
2. Additional mechanical backfilling shall be done to leave trench with 4-inch to 6-inch elevated mound on trench.

G. Unless otherwise directed by Engineer, procedures for compaction of trench backfill material shall be accomplished by close of each day's work.

3.05 CLEANING ACCESS INSTALLATION

A. Install inline cleanouts, end-of-line caps, as shown on Drawings.

B. Install inline cleanout in drain lines longer than 1,000 feet and place cleanouts no further than 1,000 feet apart in drain lines longer than 2,000 feet.

C. Install end-of-line caps at upstream end of drain lines.

3.06 FIELD QUALITY CONTROL

A. Drain Line Grade:

1. Measure by excavating down to drain every 250 feet and at the beginning and end of each line.
2. Measure drain invert elevation with a survey method accurate to 0.01 foot vertical.
3. Measure for grade at the top of pipe.
4. Drain lines with grades less than 1 percent shall be placed to the design grade within a tolerance of plus or minus 0.1 foot of design invert elevation.
5. Grades of 1 percent or steeper shall be placed to the design grade within a tolerance of plus or minus 0.2 foot of design invert elevation.
6. No reversal in grade of the drain lines shall be permitted.

B. Drain Line Stretching:

1. Drain lines shall not be stretched more than 5 percent during installation.
2. Measure stretch by measuring the distance across a minimum of 10 corrugations and comparing to manufacturer's standard corrugation dimensions.

3.07 FINAL INSPECTION AND CLEANING

A. Preparation:

1. Do not begin jet washing until subsurface drainage work within a DMU is complete.
2. Stage the Work to provide adequate supply of water for jet washing to allow inspection and cleaning of each section of drain line in one continuous operation.
3. Access to drain lines shall be through drain line cleanouts.

B. High Pressure Jet Washing Equipment:

1. Suitable type and size to perform cleaning specified herein.
2. Cleaning nozzle capable of jet washing 6-inch diameter to 15-inch diameter drain lines in sections up to 1,000 feet long.
3. Capable of negotiating 4-inch diameter cleaning access point.
4. Jet mechanism shall have a forward-piercing jet with trailing side jets that propel mechanism forward.
5. Operating pressures at pump shall not exceed a maximum of 2,300 psi.

6. Operate in accordance with manufacturer's printed instructions, recommendations, and best practice of the trade.

C. Pass high-pressure water jet cleaner through entire length of each drain line no sooner than 10 calendar days after installation of drain line.

D. When drain lines must be jet washed in sections, upstream sections shall be jet washed before connecting section downstream.

E. If tailwater produced is not clear, run jet cleaner through drain line section up to two more passes.

F. Obstructions within drain lines, collapsed drain line sections, or sections outside allowable tolerances for grade that are identified during final inspection and cleaning shall be repaired and corrected to meet Specification.

G. Complete final drain line inspection and cleaning certification of compliance addressing the following items:

1. Dates of work, equipment, and personnel performing work.
2. Locations and descriptions of obstructions, collapsed sections, out-of-grade sections, and actions taken to repair problems.
3. Locations of sections where tailwater did not run clear after three passes.

H. After completing jet washing for a drain line, restore area to a neat and finished appearance.

END OF SECTION

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SECTION 35 20 16.25
FABRICATED SLIDE GATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): C513, Open-Channel, Fabricated-Metal Slide Gates.
2. ASTM International (ASTM):
   a. A193/A193M, Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
   c. A276, Standard Specification for Stainless Steel Bars and Shapes.
   d. B209, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate.
   e. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

1.02 DEFINITIONS

A. Submersible: The ability to exclude water when submerged under a 20-foot head of fresh water for 24 hours and still maintain electrical integrity.

B. Slenderness Ratio: The ratio of the maximum unsupported stem length to the stem cross-section radius of gyration.

C. Self-Contained: The arrangement of gate operator, supported by gate frame, such that operating thrust loads are not applied external to the assembly.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, of each equipment assembly.
   b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.

c. Detailed drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment associated therewith.
d. Gate operator and stem calculations for each gate and service condition.
e. Gate opening and closing thrust forces that will be transmitted to the support structure with operator at extreme positions and load.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's written/printed installation instructions.
4. Routine maintenance requirements prior to plant startup.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 SYSTEM DESCRIPTION

A. Coordinate such that operators and gates are fully assembled and tested, at the factory.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

Item	Quantity
Stem collars for all gate stems	One of each different size
Bronze lift nuts	One of each different size
Special tools required to maintain or dismantle	One complete set

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 SUPPLEMENTS

A. See supplements to this section for additional product information.

2.02 MATERIALS

A. Aluminum Plate and Shapes: ASTM B209 and ASTM B308/B308M, Alloy 6061-T6.

B. Stainless Steel:

1. Plate, Sheet, and Strip: ASTM A240/A240M, Type 316L.
2. Bars and Shapes: ASTM A276, Type 316L.

2.03 PERFORMANCE REQUIREMENTS

A. Leakage shall not exceed 0.1 gallon per minute per foot of gate periphery under either seating or unseating head conditions.

2.04 SLIDE GATES

A. Rising stem type, with assembly styles designated as follows:

1. Style A: Upward acting type for wall surface mounting on the concrete structures.
2. Style B: Upward acting type for mounting in channels with concrete embedded frame and invert.
3. Style C: Downward acting weir gate type with P-type invert seal for wall surface mounting on the concrete structures.
4. Style D: Downward acting weir gate type with invert "P" seal for embedded side frame mounting in concrete structures.

B. Guide Frames:

1. Aluminum.
2. Vertical Guides: Design for maximum rigidity, and extend in one continuous piece from the gate invert to form posts for support of gate operators of self-contained gates. When guides extended above the operating floor, they shall be sufficiently strong so that no further reinforcements are required.
   a. Weight: Not less than 4 pounds per linear foot for aluminum.
   b. Incorporate a replaceable UHMW polyethylene bearing strip in a retainer slot on the downstream side (unseating head side) of the gate.
3. Frame Invert: For flush bottom gate, furnish a neoprene insert to function as a seating surface for the gate disc.
   a. Weight: Not less than 2 pounds per linear foot for aluminum.
4. Join vertical guide frames and invert with factory welded corners.
5. Size guided slot to provide a minimum disc engagement of 1 inch on each side.

C. Disc:

1. Disc Plate (Sliding Member): One-piece aluminum. Reinforce as required so that the disc will not deflect more than 1/360 of the gate span, when the upstream liquid depth (seating head side) is as shown on the schedule and the downstream liquid depth is less than 1/2 inch.
2. Reinforce gate disc with one-piece aluminum angles or channels welded to the disc plate. Bolted reinforcements will not be permitted.

D. Operator Support Yoke:

1. For self-contained gate operators, attached to the vertical extensions of the guide frames.
2. Constructed from at least two aluminum angles, or two other suitable shapes, and bolt in place to provide a rigid assembly.
3. Maximum Deflection: Not to exceed 1/4 inch under full operator applied loading.

E. Stems:

1. 1-inch minimum diameter, ASTM A276, Type 316 stainless steel.
2. Threads: Acme type with RMS surface roughness of 63 microinches or less on the flanks for manually operated gates and 32 microinches or less on the flanks for electrically operated gates. Extend threaded portion of stem 2 inches above operator when gate is in CLOSED position or in the lowest crest elevation for a weir gate.
3. Ratio of the unsupported stem length to the radius of gyration, both in inches, shall not exceed 200.
4. Stems to withstand in compression, without damage, the thrust equal to at least 2-1/2 times the rated output of the hoisting mechanism, with a 40-pound effort applied to the handwheel or crank.
5. Design electric motor-driven floor stands (where applicable) to withstand at least 1.25 times the output thrust of the motor in the stalled condition.
6. Equip operating stems with cast iron, bushed stem guides, mounted on cast iron brackets; adjustable in two directions and spaced so that the L/r ratio does not exceed 200.
7. Adjustable stop collar for the CLOSED or minimum crest elevation position.
8. Connect the stems to the disc plate with a yoke, bolted to the stem and welded to the disc.
9. Slide gates having a width greater than twice the height or width greater than 84 inches shall have dual stems. For downward opening weir type gates, locate stems near outside edges of gate.

F. Stem Covers:

1. Transparent plastic, vented pipe stem cover and cap.
2. Provide with OPEN/CLOSED designators with 1-inch graduations on clear mylar pressure sensitive, adhesive tape, suitable for outdoor application.
3. For weir gates provide with MIMIMUM CREST ELEVATION designator with 1-inch graduations on clear mylar pressure sensitive, adhesive tape, suitable for outdoor application.

G. Manufacturers:

1. Aluminum:
   a. Hydro Gate Corp.
   b. Rodney Hunt Co.
   c. Fontaine, Ltd.

2.05 GATE OPERATORS

A. General:

1. Components: Withstand a minimum of 250 percent of design torque or thrust at extreme operator positions without damage.
2. Mount at walkway level, 36 inches above floor, unless otherwise indicated.
3. Gear train and gate stem sections shall produce a self-locking drive train.
4. Lift Nuts: Internally threaded with cut or cold-rolled Acme threads corresponding to stem threading.
5. Roller Bearings: Ball-thrust or tapered above and below lift nut to support both opening and closing thrusts.
   a. Grease lubrication fittings for bearings.
   b. Input pinions with needle or ball bearings.
6. Lubrication: Furnish rising stem gates with an insert lubricator flange in lift, with grease fitting for greasing stem threads below stem nut.

B. Dual-Stem Gate Operators:

1. Enclosed, geared floor or bench stands.
2. Interconnect so operators will work as a unit from single point with crank lever.
3. Interconnecting Shafts:
   a. Stainless steel with flexible couplings at ends.
   b. Diameter sufficient to prevent sagging.
   c. Include flanged coupling to allow precision weir leveling.

C. Type 1, Handwheel-Operated Bench Stands:

1. Direct drive.
2. Sealed, ball thrust, roller or needle bearing type and equipped with bronze lift nut, internally threaded with Acme threads.
3. Furnish mechanical seals at housing penetrations.
4. Handwheel and Baseplate: Cast iron or cast aluminum.
5. Manual Effort: Not to exceed 40 pounds.

D. Identification Tagging Requirements:

1. For each gate operator, 1-1/2-inch minimum diameter heavy brass tag, bearing the gate tag number shown in the schedule.
2. Attach the tags to the operator by soldered split key rings to that ring and tag cannot be removed. Use block type numbers and letters with 1/4-inch minimum high numbers and letters stamped on and filled with black enamel.

2.06 APPURTENANCES

A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Anchor Bolts: ASTM A193/A193M, Type 316 stainless steel sized by equipment manufacturer at least 1/2 inch in diameter, or as shown, and as specified in Section 05 50 00, Metal Fabrications.

C. Staff Gauges: Provide for downward acting weir gates. Graduated in 1/4 inches and marked every inch and foot.

1. Manufacturer and Product: Stevens Water Monitoring Equipment; Porcelain Enameled Style C.

2.07 SHOP/FACTORY FINISHING

A. Coat all aluminum surfaces in contact with concrete with unthinned bitumastic paint in accordance with Section 09 90 00, Painting and Coating, or insulate with suitable protective neoprene gasket material.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with the manufacturer's written instructions.

B. Disassemble factory assembled gate components before installation.

C. Field mount operators after installing gates.

D. Brace thimbles internally during concrete placement, as applicable.

E. Accurately place anchor bolts using templates furnished by the manufacturer and as specified in Section 05 50 00, Metal Fabrications.

F. Lubricate stems before operating.

3.02 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each slide gate.

B. Performance Test:

1. Conduct on each slide gate.
2. Perform under actual or approved simulated operating conditions.
3. Test for a continuous 3-hour period without malfunction.
4. Adjust, realign, or modify units and retest if necessary.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

3.04 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification.

1. Slide Gate Schedule.

END OF SECTION

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SLIDE GATE SCHEDULE - FTTP						
Gate Identification No. and Location	**Assembly Style**	**Wall Opening (width/height inches)**	**Gate Height (inches)**	**Material**	**Design Operating Head (feet) Seating/Unseating Condition**	**Operator Type/ Control Style**
FT-WG-001 – at Flow Splitter Box	C = surface mounted, downward acting weir gate	72" wide x 84" high	42	Aluminum	2 feet; seating	Type 1 Handwheel/manual control
FT-WG-002 – at Flow Splitter Box	C = surface mounted, downward acting weir gate	72"wide x 84" high	42	Aluminum	2 feet; seating	Type 1 Handwheel/manual control

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SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards, which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
3. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
   c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. International Code Council (ICC):
   a. International Building Code (IBC).
   b. International Mechanical Code (IMC).
5. Manufacturers' Standardization Society (MSS):
   a. SP 58, Pipe Hangers and Supports - Materials, Design and Manufacture.
   b. SP 69, Pipe Hangers and Supports - Selection and Application.
   c. SP 89, Pipe Hangers and Supports - Fabrication and Installation Practices.
   d. SP 127, Bracing for piping Systems, Seismic-Wind-Dynamic Design, Selection and Application.

1.02 DEFINITIONS

A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping 6 inches and larger. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
2. For piping 4 inches and smaller, provide catalog information for each type of support.
3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Drawings of piping support systems shall include associated reaction forces at all support locations.

B. Informational Submittals:

1. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
2. Maintenance information on piping support system.

1.04 QUALIFICATIONS

A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a Registered Professional Engineer in the state where the Work is to be installed.

1.05 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Piping Smaller than 30 Inches: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Meet requirements of MSS SP 58, MSS SP 69, MSS SP 89, and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Pipe support systems shall be designed for gravity and thrust loads imposed by weight of pipes or internal pressures, including weight of fluid in pipes and insulation.

2. Seismic loads in accordance with governing codes and as shown on Structural General Drawings.
3. Wind loads in accordance with governing codes and as shown on Structural General Drawings.
4. Maximum support spacing and minimum rod size in accordance MSS SP-69 Table 3 and Table 4.
5. Electrical Conduit Support: Include in design of framing support system.

C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

E. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

PART 2 PRODUCTS

2.01 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Special support and hanger details may be required for cases where standard catalog supports are inapplicable.

C. Materials: In accordance with Table 1 and Table 2, attached as supplements to this section.

2.02 HANGERS

A. Clevis: MSS SP-58 and SP-69, Type 1.

1. Anvil; Figure 260, sizes 1/2 inch through 30 inches.
2. For Insulated Pipe: Anvil; Figure 260 with insulated saddle system (ISS) sizes 1/2 inch through 16 inches.
3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.

B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58 and MSS SP 69, Type 6.

1. Anvil; Figure 104, sizes 3/4 inch through 8 inches.

2. B-Line; Figure B3171, sizes 3/4 inch through 8 inches.

C. Steel Yoke Pipe Rolls and Roller supports: MSS SP 58 and MSS SP 69, Type 41 or Type 43.

1. Anvil; Figure 181, sizes 2-1/2 inches through 24 inches. Figure 171, 30 inches and sizes 1 inch through 2 inches.
2. B-Line; Figure B3110, sizes 2 inches through 24 inches. Figure B3114, 30 inches.

D. Pipe Rollers and Supports: MSS SP 58 and MSS SP 69, Type 44.

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

2.03 SADDLE SUPPORTS

A. Pedestal Type: Schedule 40 pipe stanchion, saddle, and anchoring flange.

1. Nonadjustable Saddle: MSS SP 58 and MSS SP 69, Type 37 with U-bolt.
    a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 62C base.
    b. B-Line; Figure B3090, sizes 3/4 inches through 36 inches with B3088 base.
2. Adjustable Saddle: MSS SP 58 and MSS SP 69, Type 38 without clamp.
    a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 62C base.
    b. B-Line; Figure B3093, sizes 1 inch through 36 inches with Figure B3088T base.

B. Elbow and Flange Supports:

1. Elbow with Adjustable Stanchion:
    a. Sizes 2-1/2 inches through 42 inches.
        1) Anvil; Figure 62C base.
2. Elbow with Nonadjustable Stanchion:
    a. Sizes 2-1/2 inches through 42 inches.
        1) Anvil; Figure 63C base.
3. Flange Support with Adjustable Base:
    a. Sizes 2 inches through 24 inches.
        1) B-Line; B3094, with Figure B3088T base.
        2) Standon; Model S89.

2.04 WALL BRACKETS AND SUPPORTS

A. Welded Steel Wall Bracket: MSS SP 58 and MSS SP 69, Type 33 (heavy-duty).

1. Anvil; Figure 199, 3,000-pound rating.
2. B-Line; Figure B3067, 3,000-pound rating.

B. Adjustable "J" hanger MSS SP 58 and MSS SP 69, Type 5:

1. Anvil; Figure 67, sizes 1/2 inch through 8 inches.
2. B-Line; Figure B3690, sizes 1/2 inch through 8 inches.

C. Offset Pipe Clamp:

1. Anvil; Figure 103, sizes 3/4 inch through 8 inches.
2. B-Line; Figure B3148, sizes 1/2 inch through 12 inches.

D. Channel Type:

1. Unistrut.
2. Anvil; Power-Strut.
3. B-Line; Strut System.
4. Aickinstrut (FRP).

2.05 PIPE CLAMPS

A. Riser Clamp: MSS SP 58 and MSS SP 69, Type 8.

1. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
2. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

2.06 STEEL PIPE SADDLES

A. Provide 120-degree pipe saddle with bolted segmented saddle plates.

1. Sizes 20 inches though 60 inches.
2. Manufacturer: Piping Technology & Products, Inc.; Fig. 2000 as modified per above.

2.07 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.

B. Members and Connections: Design for loads using one-half of manufacturer's allowable loads.

C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts, or encapsulated steel fasteners.

D. Manufacturers and Products:

1. B-Line; Strut System.
2. Unistrut.
3. Anvil; Power-Strut.
4. Aickinstrut (FRP System).
5. Enduro-Durostrut (FRP Systems).

2.08 FRP PIPE SUPPORTS SYSTEMS

A. General:

1. FRP systems include hangers, rods, attachments, and fasteners.
2. FRP with vinyl ester resins resistance to the chemicals listed in the supplements.
3. Fire retardant to ASTM E84.
4. With UV additive and a protective veil.

B. Clevis Hangers:

1. Factor of Safety: 3 to 1.
2. Minimum Design Load: 200 pounds.

C. Design:

1. Pipe supports spacing, hanger rod sizing to be designed based upon the manufacturer's recommendations.
2. Identify and highlight non-FRP fasteners or components in the submittal.

D. Manufacturers:

1. Aickinstrut.
2. Enduro.
3. Century Composite.

2.09 SEISMIC RESTRAINTS

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

B. Manufacturer: Mason Industries.

2.10 ACCESSORIES

A. Insulation Shields:

1. Type: Galvanized steel or stainless steel, MSS SP 58 and MSS SP 69, Type 40.
2. Manufacturers and Products:
   a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
   b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.

B. Welding Insulation Saddles:

1. Type: MSS SP 58 and MSS SP 69, Type 39.
2. Manufacturers and Products:
   a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
   b. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.

C. Plastic Pipe Support Channel:

1. Type: Continuous support for plastic pipe and to increase support spacing.
2. Manufacturer and Product: B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hangers.

D. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

E. Attachments:

1. I-Beam Clamp: Concentric loading type, MSS SP 58 and MSS SP 69, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
2. Concrete Insert: MSS SP 58 and MSS SP 69, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
3. Welded Beam Attachment: MSS SP 58 and MSS SP 69, Type 22.
   a. Anvil; Figure 66.
   b. B-Line; Figure B3083.
4. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
5. Concrete Attachment Plates:
   a. Anvil; Figure 47, Figure 49 or Figure 52.
   b. B-Line; Figure B3084, Figure B3085 or Figure B3086.

2.11 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.

1. Manufacturer and Product: B-Line; Figure B3552, 1-1/2 inches through 30 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe. MSS SP 58 and MSS SP 69, Type 24.

1. Anvil; Figure 137 and Figure 137S.
2. B-Line; Figure B3188 and Figure B3188NS.

2.12 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes: 1/2 inch through 24 inches.

2.13 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.14 ANCHORING SYSTEMS

A. Size and Material: Sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 69 and MSS SP 89, unless shown otherwise.
2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
3. Support piping connections to equipment by pipe support and not by equipment.

4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
7. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
8. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
9. Install lateral supports for seismic loads at changes in direction.
10. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
11. Repair mounting surfaces to original condition after attachments are made.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
    a. Single Pipes: Adjustable swivel-ring, split-ring, or clevis hangers.
    b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
    a. Single Pipes: Wall brackets or wall clips attached to wall with anchors. Clips attached to wall mounted framing also acceptable.
    b. Stacked Piping: Wall mounted framing system and clips acceptable for piping smaller than 3-inch minimal diameter.
    c. Piping clamps that resist axial movement of pipe through support are not acceptable. Use cast iron hanging rolls supported from wall bracket.
3. Horizontal Piping Supported from Floors:
    a. Stanchion Type:
        1) Pedestal type; adjustable with stanchion, saddle, and anchoring flange.
        2) Use yoked saddles for piping whose centerline elevation is 18 inches or greater above floor and for exterior installations.
        3) Provide minimum 1-1/2-inch grout beneath base plate.
    b. Floor Mounted Channel Supports:
        1) Use for piping smaller than 3-inch nominal diameter running along floors and in trenches at piping elevations lower than can be accommodated using pedestal pipe supports.
        2) Attach channel framing to floors with base plate on minimum 1-1/2-inch grout and with anchor bolts.
        3) Attach pipe to channel with clips or pipe clamps.

c. Concrete Cradles: Use for piping larger than 3 inches along floor and in trenches at piping elevations lower than can be accommodated using stanchion type.

4. Insulated Pipe:
   a. Pipe hanger and support shall be on outside of insulation and shall not be enclosed within insulation.
   b. Provide precut 120-degree sections of rigid insulation (minimum length same as the shield), galvanized steel shields and oversized hangers or insulated saddle system. Anvil; Figure 260 (ISS).
   c. Wall mounted piping clips not acceptable for insulated piping.
5. Vertical Pipe: Support with wall brackets and base elbow or riser clamps on floor penetrations.
6. Standard Attachments:
   a. To Concrete Ceilings: U-Channel Concrete Inserts, U-Channel to Concrete Attachment Plates.
   b. To Steel Beams: I-beam clamp or welded attachments.
   c. To Wooden Beams: Lag screws and angle clips to members not less than 2-1/2 inches thick.
   d. To Concrete Walls: Concrete inserts or brackets or clip angles with anchor bolts.
   e. To Concrete Beams: U-Channel Concrete Inserts, or if inserts are not used attach to vertical surface similar to Concrete Wall. Do not drill into beam bottom.
   f. Existing Walls and Ceilings: Install as specified for new construction, unless shown otherwise.

C. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides (or pipe supports that provide same function) at expansion joints and loops.
2. Guide piping on each side of expansion joint or loop at four pipe and 14-pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

D. Accessories:

1. Insulation Shield: Install on insulated piping. Oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe. Oversize rollers and supports.

3. Dielectric Barrier:
   a. Provide plastic coated hangers, or isolation tape such as B-Line Iso Pipe, B-Line B1999 Vibra Cushion, or B-Line B3195 Felt Isolators between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
   b. Install 1/4-inch by 3-inch neoprene rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09 90 00, Painting and Coating.

3.03 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification:

1. Table 1: Nonchemical Areas.
2. Table 2: Chemical Areas.

END OF SECTION

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Table 1
Nonchemical Areas

Exposure Conditions	Support Material
Office Areas	Galvanized steel or precoated steel, plastic coat hangers for uninsulated copper or stainless steel piping
Shops and Warehouse Areas	Galvanized steel or precoated steel, plastic coat hangers for uninsulated copper or stainless steel piping
Pipe Galleries	Stainless steel or FRP
Process areas: high humidity	Stainless steel or FRP
Process areas: wetted or submerged	Stainless steel or FRP
Pipes conveying chemicals listed in Table 2	Provide with corresponding support per Table 2.

Notes:

1. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
2. Stainless steel to be Type 304 except in GAC areas where 316 is required.
3. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
4. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

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Table 2
Chemical Areas

Exposure Conditions	Support for Direct Exposure	Support for Remote Exposure
Alum	FRP	Precoated steel
Aqua Ammonia	Stainless steel	Precoated steel
Coagulants	FRP	Precoated steel or galvanized steel
Ferric Chloride	FRP	Precoated steel
Ferric Sulfate	FRP	Precoated steel
Hydrofluorosilic Acid	FRP	Precoated steel
Lime	Stainless steel; FRP, precoated steel	Stainless steel; FRP, precoated steel
Polymers	FRP	Precoated steel
Potassium Permanganate	Precoated steel	Precoated steel
Powdered Activated Carbon	Precoated steel	Precoated steel
Sodium Carbonate	Stainless steel	Precoated steel
Sodium Hydroxide	Stainless steel	Precoated steel
Sodium Hypochlorite	FRP	Precoated steel
Sulfuric Acid	Stainless steel	Precoated steel

Notes:

1. Direct exposure includes entire area within containment area; area within 20 feet horizontal and 10 feet vertical of chemical pumps or chemical mixing stations; or as specified.
2. Remote exposure is area beyond area defined as direct exposure, but within designated building.
3. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
4. Stainless steel to be Type 304 except for GAC areas where 316 is required.
5. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
6. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

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SECTION 40 05 33
PIPE HEAT TRACING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

1. Heating load to be calculated based upon a 50 degree F delta, 20 mph wind if pipes are located outdoors, insulation as specified in Section 40 42 13, Process Piping Insulation, pipe as specified in Section 40 27 00, Process Piping—General, and shall include a 10 percent safety factor.
2. Heat loss calculations shall be based on IEEE 515, Equation 1, Page 19.

2.02 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, FRP, and stainless steel pipe applications.

B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.

C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).

D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).

E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.

F. Manufacturers and Products:

1. Raychem; BTV-CR.
2. Thermon; BSX.
3. Nelson; CL1-J1 or L1-J1.
4. Approved Equal.

2.03 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.

C. Manufacturers and Products:

1. Power Connection Kit:
   a. Raychem; JBS-100.
   b. Thermon; PCA-1-SR or DP-L.
   c. Nelson; PLT-BC.
   d. Approved Equal.
2. Splice Kit:
   a. Raychem; S-150.
   b. Thermon; PCS-1-SR.
   c. Nelson; PLT-BS.
   d. Approved Equal
3. Tee Kit:
   a. Raychem; T-100.
   b. Thermon; DS-S.
   c. Nelson; PLT-BY.
   d. Approved Equal.
4. End Seal Kit:
   a. Raychem; E-150.
   b. Thermon; DE-S.
   c. Nelson; LT-ME.

d. Approved Equal.

5. Lighted End Seal Kit:
    a. Raychem; E-100-L.
    b. Thermon; DLS.
    c. Nelson; LT-L.
    d. Approved Equal

2.04 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.
2. Manufacturers and Products:
    a. Raychem; AT-180.
    b. Thermon; AL-20P.
    c. Nelson; AT-50.
    d. Approved Equal

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.
2. Manufacturers and Products:
    a. Raychem; GS54 or GT66.
    b. Thermon; PF-1.
    c. Nelson; GT-6 or GT-60.
    d. Approved Equal

2.05 PIPE MOUNTED THERMOSTAT

A. Type: Fixed, nonadjustable, set at 40 degrees F or temperature as required by the system being protected.

B. Sensor: Fluid-filled with 3-foot capillary.

C. Enclosure: Glass-filled nylon, NEMA 250, Type 4X weatherproof with gasketed lid.

D. Switch: SP-ST, UL listed, rated 22 amps, 120 to 240V ac.

E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-F5.
2. Thermon; E4X-1.
3. Raychem; DigiTrace Model E507S-LS for hazardous areas.
4. Thermon; E7-25325 for hazardous areas.
5. Approved Equal.

2.06 AMBIENT THERMOSTAT

A. Type: Adjustable setting (15 to 140 degrees F).

B. Sensor: Fluid-filled probe.

C. Enclosure: Epoxy-coated NEMA 250, Type 4X aluminum enclosure with exposed hardware of stainless steel.

D. Switch: SP-DT, UL or FM listed, rated 22 amps, 125 to 250V ac.

E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-1A.
2. Thermon; B4X-15140.
3. Raychem; DigiTrace Model AMC-1H for hazardous areas.
4. Thermon; B7-15140 for hazardous areas.
5. Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install in accordance with the manufacturer's instructions and recommended practices.
2. Provide insulation as specified in Section 40 42 13, Process Piping Insulation, over all pipe heat tracing.
3. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.
4. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
5. Provide end of circuit pilot lights on heat tracing circuits for buried piping or piping installed in duct banks .

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.

4. Install on services as follows:

Service	Piping Material	Location
Caustic Soda	PVC	All pipe unless otherwise noted on the contract drawings

5. Install additional heating tape at bolted flanges, valves, pipe supports, and other fittings and fixtures as recommended by supplier, but not less than the following:

Item	Heating Tape Length (min. feet)
Valves	Four times valve length
Pipe hanger or support penetrating insulation	Three times pipe diameter

C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 40 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.

D. Thermostats:

1. Install in accordance with manufacturer's instructions and as approved by Engineer.
2. For each group of heat traced circuit, install one ambient thermostat.

3.02 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

END OF SECTION

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SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards, which may be referenced in this section and any supplemental Data Sheets:

1. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges.
2. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
3. American Society of Mechanical Engineers (ASME):
   a. Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels.
   b. Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   c. B1.20.1, Pipe Threads, General Purpose (Inch).
   d. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   e. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
   f. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
   g. B16.9, Factory-Made Wrought Buttwelding Fittings.
   h. B16.11, Forged Fittings, Socket-Welding and Threaded.
   i. B16.15, Cast Bronze Threaded Fittings Classes 125 and 250.
   j. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   k. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   l. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500, and 2500.
   m. B16.25, Butt Welding Ends.
   n. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
   o. B31.1, Power Piping.
   p. B31.3, Process Piping.
   q. B31.9, Building Services Piping.
   r. B36.10M, Welded and Seamless Wrought Steel Pipe.
   s. B36.19M, Stainless Steel Pipe.
4. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.

5. American Water Works Association (AWWA):
    a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
    b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
    c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings for Water.
    d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
    e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
    f. C116/A21.16, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.
    g. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water.
    h. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
    i. C200, Steel Water Pipe - 6 In. (150 mm) and Larger.
    j. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied.
    k. C206, Field Welding of Steel Water Pipe.
    l. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
    m. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
    n. M11 (Manual), Steel Pipe - A Guide for Design and Installation.
    o. C606, Grooved and Shouldered Joints.
6. American Welding Society (AWS):
    a. Brazing Handbook.
    b. A5.8/A5.8M, Specification for Filler Metals for Brazing and Braze Welding.
    c. D1.1/D1.1M, Structural Welding Code - Steel.
    d. QC1, Standard for AWS Certification of Welding Inspectors.
7. ASTM International (ASTM):
    a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
    b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
    c. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
    d. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
    e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
    f. A135/A135M, Standard Specification for Electric-Resistance-Welded Steel Pipe.

g. A139/A139M, Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over).
h. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
i. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
j. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
l. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
n. A197/A197M, Standard Specification for Cupola Malleable Iron.
o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
q. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
r. A276, Standard Specification for Stainless Steel Bars and Shapes.
s. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
t. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
u. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
v. A320/A320M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service.
w. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
x. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
y. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
z. A409/A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
aa. A536, Standard Specification for Ductile Iron Castings.

bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
cc. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
dd. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
ee. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
ff. B32, Standard Specification for Solder Metal.
gg. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
hh. B61, Standard Specification for Steam or Valve Bronze Castings.
ii. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
jj. B75, Standard Specification for Seamless Copper Tube.
kk. B88, Standard Specification for Seamless Copper Water Tube.
ll. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
mm. B462, Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, and UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
nn. B464, Standard Specification for Welded UNS N08020, N08024, and N08026 Alloy Pipe.
oo. B474, Standard Specification for Electric Fusion Welded Nickel and Nickel Alloy Pipe.
pp. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
qq. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension.
rr. D413, Standard Test Methods for Rubber Property Adhesion to Flexible Substrate.
ss. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
tt. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
uu. D1330, Standard Specification for Rubber Sheet Gaskets.
vv. D1784, Standard Specification for Rigid PolyVinyl Chloride) (PVC) Compounds and Chlorinated Poly Vinyl Chloride) (CPVC) Compounds.

ww. D1785, Standard Specification for Polyvinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
xx. D2000, Standard Classification System for Rubber Products in Automotive Applications.
yy. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
zz. D2464, Standard Specification for Threaded Poly Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
aaa. D2466, Standard Specification for Poly Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
bbb. D2467, Standard Specification for Poly Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
ccc. D2564, Standard Specification for Solvent Cements for Poly Vinyl Chloride) (PVC) Plastic Piping Systems.
ddd. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
eee. D2996, Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
fff. D3222, Standard Specification for Unmodified Poly Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
ggg. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
hhh. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
iii. D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials.
jjj. D4895, Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion.
kkk. F436, Standard Specification for Hardened Steel Washers.
lll. F437, Standard Specification for Threaded Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
mmm. F439, Standard Specification for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
nnn. F441/F441M, Standard Specification for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
ooo. F493, Standard Specification for Solvent Cements for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
ppp. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

8. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought Stainless Steel Butt-Welding Fittings.
9. NSF International (NSF): 61 Drinking Water System Components—Health Effects.
10. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
11. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.02 DEFINITIONS

A. Submerged or Wetted:

1. Zone below elevation of:
   a. Top face of channel walls and cover slabs.
   b. Liquid surface or within 1.5 feet above top of liquid surface.
2. Fittings and Specials: Including, but not limited to fittings, closure pieces, bends, elbows, reducers, tees, wyes, bifurcations, crosses, outlets, manifolds, nozzles, wall sleeves, bulkheads, and other piping and appurtenances fabricated from steel plate, sheet, or coils as required to provide the Work, complete. Specials shall also include piping above ground or inside structures.

1.03 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
3. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code ICBO/IAPMO Uniform Plumbing Code BOCA Uniform Plumbing Code Local plumbing code.
4. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
5. Thrust Restraints:
   a. Design for test pressure shown in Piping Schedule.
   b. Allowable Soil Pressure: 1,000 pounds per square foot.

c. Low Pressure Pipelines:
1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.
2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

6. Steel Pipe: Design piping in accordance with AWWA Manual M11, AWWA C200, and AWWA C208.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
   a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, buried, submerged, or concrete encased if thickness not shown or specified.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods. Submit design for thrust lugs and rods for steel pipe.
4. Thrust Blocks: Concrete quantity, bearing area on pipe, and fitting joint locations.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Pipe Corrosion Protection: Product data.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance:
   a. Pipe and fittings.
   b. Welding electrodes and filler materials.
   c. Factory applied resins and coatings.
2. Qualifications:
   a. Weld Inspection and Testing Agency: Certification and qualifications.
   b. Welding Inspector: Certification and qualifications.

c. Welders:
    1) List of qualified welders and welding operators.
    2) Current test records for qualified welder(s) and weld type(s) for factory and field welding.

3. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
4. Nondestructive inspection and testing procedures.
5. Test logs.
6. Pipe coating applicator certification.
7. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.
8. Certified welding inspection and test results.
9. Certification that pipe meets NSF 61 requirements.
10. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
    a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
    b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
    c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
    d. Testing Personnel: Qualified for nondestructive test methods to be performed.
    e. Inspection Services: Qualified welding inspector.
2. Welding Inspector: AWS certified, AWS QC1 qualified, with prior inspection experience of welds specified.
3. Welder and Welding Operator Qualifications:
    a. Qualified by accepted inspection and testing agency before starting Work in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code.
    b. Qualified to perform groove welds in Positions 2G and 5G for each welding process and pipe material specified.
    c. Qualification tests may be waived by Engineer based on evidence of prior qualification.

B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

C. Quality Control: Provide services of independent inspection and testing agency for welding operations.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 PIPING

A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Per standard.

2.02 JOINTS

A. Grooved End System:

1. Rigid type.
2. Use of flexible grooved joints will only be allowed where shown on Drawings or with prior approval by Engineer.

3. Couplings: Couplings shall consist of two or more ductile iron housing segments, pressure responsive gasket, and zinc-electroplated steel bolts and nuts.
   a. AWWA Ductile Iron Piping: Victaulic Series 31, with FlushSeal® gaskets or approved equal. For direct connection to steel pipe sizes, Victaulic Style 307, or approved equal, transition couplings with offsetting angle-pattern bolt pads.
   b. Steel Piping: Victaulic Installation Ready Style 107 (rigid), or approved equal, for direct stab installation without field disassembly or loose parts; or Victaulic Style 07 Zero-Flex and Style 77 or approved equal.
      1) 14" through 36": Victaulic AGS series consisting of two housings with lead-in chamfer on housing key and wide width FlushSeal® gasket or approved equal
         a) Rigid Type: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style W07 or approved equal.
   c. Stainless Steel Piping: Victaulic Style 489 (rigid), or approved equal, with stainless steel housings.
4. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.
   a. Ductile Iron Pipe: Victaulic Style 341 or approved equal.
   b. Steel Pipe: Victaulic Style 741/W741 (Class 150) or approved equal.
   c. Stainless Steel Pipe: Victaulic Style 441 or approved equal.

B. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

D. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with breakoff tightening bolts. Thrust rated to 250 psi minimum. Rated operating deflection not less than 2-1/2 degrees. UL and FMG approved.

2. Manufacturers and Products:
   a. EBAA Iron Inc.; Megalug.
   b. Romac Industries, Inc.; RomaGrip.
   c. Ford Meter Box Co.; Series 1400.
   d. Approved Equal

E. Flexible Mechanical Compression Joint Coupling:

1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Fernco Joint Sealer Co.
   c. Approved Equal

F. Mechanical connections of high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through flanged connections consisting of the following:

1. A polyethylene stub end thermally butt-fused to end of pipe.
2. ASTM A240/A240M, Type 304 stainless steel backing flange, 125-pound, ASME B16.1 standard. Insulating flanges shall be used where shown.
3. Bolts and nuts of sufficient length to show a minimum of three complete threads when the joint is made and tightened to manufacturer's standard. Retorque nuts after 4 hours.
4. Gaskets as specified on Data Sheet.

2.03 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or "or-equal" will be allowed.

2.04 DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. All system components shall be pre-engineered, factory fabricated, tested, and assembled such that field assembly is minimized to primarily that of straight joints.

2.05 PIPE CORROSION PROTECTION

A. Coatings: See Section 09 90 00, Painting and Coating, for details of coating requirements.

B. Insulating Flanges, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.9 or B31.3 working pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.
2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger: Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts. Bolt insulating sleeves shall be provided full length between insulating washers. Contractor shall be responsible for fit-up of all components of insulated flange assembly to provide a complete functioning installation. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of all required washers, flanges and gasket.
4. Flange Insulating Kits:
   a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
   b. Insulating Sleeves: Full-length mylar.
   c. Insulating Washers: High strength phenolic.
   d. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
      1) Provide two washers per bolt for flange diameters equal to or less than 36-inch.
      2) Provide four washers per bolt for flange diameters larger than 36-inch.
5. Manufacturers and Products:
   a. Dielectric Flanges and Unions:
      1) PSI, Houston, TX.
      2) Advance Products and Systems, Lafayette, LA.
      3) Approved Equal
   b. Insulating Couplings:
      1) Dresser; STAB-39.
      2) Baker Coupling Company, Inc.; Series 216.
      3) Approved Equal.

2.06 THRUST BLOCKS

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 THRUST TIES

A. Steel Pipe: Fabricated lugs and rods designed for thrust restraint. Submit design for approval.

2.08 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer's identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Flanged pipe shall be fabricated in the shop, not in the field, and delivered to the Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the manufacturer.

2.09 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

B. Galvanizing:

1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Welding Electrodes: Verify proper grade and type, free of moisture and dampness, and coating is undamaged.

3.02 PREPARATION

A. See Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

D. Inspect grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe/fitting end to groove.

E. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Mark each weld with symbol identifying welder.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.

3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or high wind on the weld area, or if the ambient temperature is below 32 degrees F.
2. Stainless Steel and Alloy Piping: If the ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Passes: As required in welding procedure.

J. Weld Quality: Free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.

3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer or grooved joint flange adapter manufacturer.

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Grooved-End Joints:

1. Piping shall be grooved in accordance with the manufacturer's latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer's standards and to AWWA C606.
2. Install grooved joint couplings and gaskets in accordance with manufacturer's latest published installation instructions.
3. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

F. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

G. Brazed Joints for Refrigerant Piping:

1. Braze copper piping with silver solder complying with AWS A5.8/A5.8M.
2. Construct joints according to AWS Brazing Handbook, Chapter Pipe and Tube.
3. Inside of tubing and fittings shall be free of flux.
4. Clean parts to be joined with emery cloth and keep hot until solder has penetrated the full depth of the fitting and extra flux has been expelled.
5. Cool joints in air and remove flame marks and traces of flux.
6. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel the air.
7. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

H. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.

I. PVC and CPVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

J. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.
   c. Push-On Joints: Bevel, as recommended by pipe manufacturer.

d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal. Grooved joints may be utilized to facilitate installation and removal, subject to approval by the Engineer.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.

6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, behind, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.06 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

   1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.
   2. Buried: Wrap with polyethylene bagging.
   3. Submerged or Embedded: Coat with NSF 61 approved epoxy as specified in Section 09 90 00, Painting and Coating.

B. Carbon Steel Pipe:

   1. Exposed: As specified in Section 09 90 00, Painting and Coating.
   2. Submerged or Embedded: Shop coat with NSF 61 approved epoxy as specified in Section 09 90 00, Painting and Coating.

C. Copper Pipe:

   1. Exposed: As specified in Section 09 90 00, Painting and Coating.

D. PVC and CPVC Pipe, Exposed: As specified in Section 09 90 00, Painting and Coating.

E. Piping Accessories:

   1. Exposed:
      a. To match the adjoining pipe.
      b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners. Field coat as specified in Section 09 90 00, Painting and Coating, as applicable to base metal material.

F. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer's instructions.

G. Insulating Flanges, Couplings, and Unions:

   1. Applications:
      a. Dissimilar metal piping connections.

b. Cathodically protected piping penetration to buildings and watertight structures.
c. Submerged to unsubmerged metallic piping connections.
d. Connections to existing metallic pipe.
e. Where required for electrically insulated connection.

2. Pipe Installation:
   a. Insulating joints connecting immersed piping to non-immersed piping shall be installed above maximum water surface elevation.
   b. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
   c. Align and install insulating joints as shown n the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.07 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with lugs fabricated for thrust restraint. Submit design for approval.
2. Ductile Iron Pipe: Attach with socket clamps anchored against a grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through the coupling sleeve or use dismantling joints.

3.08 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.09 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including the first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at a tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.
3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.10 INSULATION

A. See Section 40 42 13, Process Piping Insulation.

B. Install insulation where shown or specified.

3.11 HEAT TRACING

A. See Section 40 05 33, Pipe Heat Tracing.

3.12 DISINFECTION

A. See Section 33 13 00, Disinfecting of Water Utility Distribution.

3.13 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of any surface preparation or coating application work.

B. As specified in Section 09 90 00, Painting and Coating.

3.14 PIPE IDENTIFICATION

A. As specified in 09 90 00, Painting and Coating and 10 14 00, Signage.

3.15 FIELD QUALITY CONTROL

1. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.
   a. General:
      1) Notify Engineer in writing 5 days prior to testing. Perform testing in presence of Engineer.
      2) Test newly installed pipes using water as test medium. Pipes shall successfully pass a leakage test prior to acceptance.
      3) Furnish testing equipment and perform tests in manner satisfactory to Engineer. Testing equipment shall provide observable and accurate measurements of leakage under specified conditions.
      4) Isolate new pipes that are connected to existing pipelines.
      5) Conduct field hydrostatic test on buried piping after trench has been completely backfilled. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.
      6) Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
      7) Supply of temporary water shall be as stated in Section 01 50 00, Temporary Facilities and Controls.
      8) Dispose of water used in testing.
   b. Procedure:
      1) Maximum filling velocity shall not exceed 0.25 foot per second, calculated based on the full area of pipe.
      2) Expel air from pipe system during filling. Expel air through air release valve or through corporation stop installed at high points and other strategic points.
      3) Test Pressure: 100 psi above system operating pressure, but in no case less than 125 psi as measured at the low point of the pipe.
      4) Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
      5) Maintain hydrostatic test pressure continuously for 2 hours minimum, adding additional make-up water only as necessary to restore test pressure.

6) Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
7) If measured leakage exceeds allowable leakage or if leaks are visible, repair defective pipe section and repeat hydrostatic test.

c. Allowable Leakage: No leakage will be allowed for exposed pipe. Contractor shall repair all visible leaks. For buried pipe that can be tested completely separate from exposed pipe, maximum allowable leakage for pipe with O-ring rubber gasket joints shall not exceed 2 gallons per inch of diameter per mile per 2 hours and maximum allowable leakage for pipe with welded joints shall not exceed 0.02 gallon per inch of diameter per mile per 2 hours.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code, ASME B31.3.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for all piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.16 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services.Manufacturer's representative shall complete a Manufacturer's Certificate of Proper Installation. Inspection and examination practices shall be according to ASME B31.3 for normal fluid service.

3.17 CLEANING

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines (except as stated below) with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris, plant process air, instrument air-lines with compressed air at 4,000 fpm; do not flush with water.

C. Immediately after cleaning service piping, dry to minus 40 degrees F dew point with dry compressed instrument air or compressed commercial grade nitrogen.

D. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

E. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

F. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.18 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Piping Schedule.
2. Data Sheets.

Number	**Title**
40 27 00.01	Cement-Mortar -Lined Ductile Iron Pipe and Fittings
40 27 00.02	Carbon Steel Pipe and Fittings—Special Service
40 27 00.03	Carbon Steel Pipe and Fittings—General Service
40 27 00.08	Stainless Steel Pipe and Fittings—General Service
40 27 00.09	Stainless Steel Pipe and Fittings—Special Service
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings

Number	Title
40 27 00.11	Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings
40 27 00.13	Copper and Copper Alloy Pipe, Tubing, and Fittings

END OF SECTION

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SECTION 40 27 00.01
CEMENT-MORTAR-LINED
DUCTILE IRON PIPE AND FITTINGS

Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	Buried Liquid Service Using Push-On, Mechanical, or Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Exposed Pipe Using Rigid Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-Mortar: AWWA C104/A21.4.
Fittings	Lined and coated same as pipe Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 gray or ductile iron, 250 psi minimum working pressure. Follower glands shall be ductile iron. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure. Victaulic or approved equal. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.
Joints	Mechanical: 250 psi minimum working pressure. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure. Victaulic or approved equal. Flange: Class 125 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. Branch connections 3 inches and smaller, shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536. Victaulic or approved equal. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536. Victaulic or approved equal.

SECTION 40 27 00.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Class 125 Flat-Faced Flange: ASTM A307, Grade A carbon steel hex head bolts and ASTM A563, Grade A carbon steel hex head nuts.
Gaskets	Mechanical, and Proprietary Restrained Joints; Water and Sewage Service: Rubber conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water and Sewage Service: 1/8-inch-thick, red rubber (SBR), hardness 80 (Shore A), rated to 200 degrees F, conforming to ASME B16.21, AWWA C207, and ASTM D1330, Grades 1 and 2. Full face for Class 125 flat-faced flanges, flat-ring type for Class 250 raised-face flanges. Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer's standard.

END OF SECTION

SECTION 40 27 00.02
CARBON STEEL PIPE AND FITTINGS—SPECIAL SERVICE

Item	Size	Description
General		Materials in contact with potable water shall conform to NSF 61 acceptance
Pipe		Black carbon steel, ASTM A106/A106M, Grade B seamless or ASTM A53/A53M, Grade B seamless or ERW. Threaded, butt-welded, and flanged joints:
	1-1/2" & smaller	Schedule 80.
	2" thru 10"	Schedule 40, except 4-inch and smaller in chlorine service; Schedule 80.
	12" thru 16"	Schedule 30.
	18" thru 24"	Schedule 20.
Joints	2" & smaller	Threaded or socket-welded; flanged at equipment as required or shown.
	2-1/2" & larger	Butt-welded or flanged at valves and equipment.
Fittings	2" & smaller	Threaded or socket-weld, forged carbon steel, ASTM A105/A105M, 2,000- or 3,000-pound WOG (3,000-pound chlorine service), conforming to ASME B16.11; bore to match pipe inside diameter.
	2-1/2" & larger	Wrought carbon steel butt-welding, ASTM A234/A234M, Grade WPB meeting the requirements of ASME B16.9; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise.
Branch Connections	2" & smaller	Threadolet or socket in conformance with Fittings above.
	2-1/2" & larger	Butt-welding tee in accordance with Fittings above.

SECTION 40 27 00.02
CARBON STEEL PIPE AND FITTINGS—SPECIAL SERVICE

Item	Size	Description
Flanges	2" & smaller	Forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 socket-weld or threaded, 1/16-inch raised face.
	2-1/2" & larger	Forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 slip-on or welding neck, 1/16-inch raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings.
Unions	2" & smaller	Threaded or socket-weld, forged carbon steel, ASTM A105/A105M, 2,000- or 3,000-pound WOG, integral ground steel-to-steel seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe. Chlorine Service: Threaded or socket-weld end ammonia type tongue-and-groove flange union, ASTM A105/A105M forged carbon steel, 1,500-pound two-bolt oval type.
Bolting	All	Carbon steel ASTM A193/A193M, Grade B7 studs and ASTM A194/A194M, Grade 2H hex head nuts. Quench and temper for chlorine service. When mating flange on equipment is cast iron and gasket is flat ring, provide ASTM A307, Grade B hex head bolts and ASTM A563, Grade A heavy hex nuts. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts and ASTM A194/A194M, Grade 8M hex nuts.
Gaskets	All flanges	General Service: 1/16-inch-thick compressed nonasbestos composition flat ring type. Garlock, Style 3000; Manville, Style 978 or approved equal. Chlorine Unions: Chemical lead, 2 percent to 4 percent antimony, 1/8-inch thick.

SECTION 40 27 00.02 CARBON STEEL PIPE AND FITTINGS—SPECIAL SERVICE		
Item	**Size**	**Description**
Thread Lubricant		General Service: 100 percent virgin PTFE Teflon tape. Chlorine Service: White lead paste or litharge and glycerine.

END OF SECTION

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SECTION 40 27 00.03
CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
General		Materials in contact with potable water shall conform to NSF 61 acceptance
Pipe	All	Black carbon steel, ASTM A106/A106M, Grade B seamless or ASTM A53/A53M, Grade B seamless or ERW. Threaded, butt-welded, grooved end, and flanged joints: C200, Steel Water Pipe - 6 In. (150 mm) and Larger. C208, Dimensions for Fabricated Steel Water Pipe Fittings. M11 (Manual), Steel Pipe - A Guide for Design and Installation.
	Screwed:	
	2" & smaller	Schedule 40.
	Welded:	
	2-1/2" thru 10"	Schedule 40.
	12" thru 16"	Schedule 30.
	18" thru 24"	Schedule 20 or approved design
	Grooved:	
	2-1/2" thru 6"	Schedule 40.
	8" thru 12" inch	Schedule 30.
	14"	Standard weight or approved design
Joints	2" & smaller	Threaded or flanged at valves and equipment or grooved end meeting the requirements of AWWA C606.
	2-1/2" & larger	Butt-welded, grooved or flanged. Flanged at valves and equipment. Grooved end meeting the requirements of AWWA C606.

SECTION 40 27 00.03
CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Fittings	2" & smaller	Threaded: 150- or 300-pound malleable iron, ASTM A197/A197M or ASTM A47/A47M, dimensions in accordance with ASME B16.3. Grooved End: Malleable iron ASTM A47/A47M or ductile iron ASTM A536, grooved ends to accept couplings without field preparation.
	2-1/2" & larger	Butt Welded: Wrought carbon steel butt-welding, ASTM A234/A234M, Grade WPB meeting the requirements of ASME B16.9; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise. Grooved End: Malleable iron ASTM A47/A47M, ductile iron ASTM A536, forged steel ASTM A234/A234M, or factory fabricated from ASTM A53/A53M pipe. Grooved ends to accept couplings without field preparation.
Branch Connections	2" & smaller	For threaded pipe: Threaded, straight, or reducing tees in conformance with Fittings specified above. For welded or grooved pipe, use threadolet.
	2-1/2" & larger	Butt-welding or grooved end tee in conformance with Fittings specified above.
Flanges	2" & smaller	Forged carbon steel, ASTM A105/A105M, Grade II, ASME B16.5 Class 150 or Class 300 socket-weld or threaded, 1/16-inch raised face.

SECTION 40 27 00.03
CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
	2-1/2" & larger	Butt-Welded Systems: Forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 slip-on or welding neck, 1/16-inch raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Grooved End Adapter Flange: Malleable iron ASTM A47/A47M or ductile iron ASTM A536. Victaulic Style 741 or 743; Anvil International, Inc., Gruvlok Figure 7012 or 7013; Shurjoint Model 7041-A or approved equal. Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment. Iron Mating Flange: AWWA C207, Class D or E, hub or ring type to mate with ASME B16.1, Class 125 cast-iron flange. AWWA C207 Class F hub type or ASTM A105/A105M, ASME B16.5 Class 300 to mate with ASME B16.1 Class 250 cast-iron flange.
Unions	2" & smaller	Threaded malleable iron, ASTM A197/A197 or ASTM A47/A47M, 150- or 300-pound WOG, meeting the requirements of ASME B16.3.
Couplings	2-1/2" & larger	Grooved End: Rigid joint malleable iron, ASTM A47/A47M or ductile iron, ASTM A536. Victaulic Co.; Anvil International, Inc., Gruvlok; Shurjoint Piping Products or approved equal. Screwed End: Malleable iron, ASTM A197/A197M or ASTM A47/A47M.

SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Bolting	All	Flanges: Carbon steel ASTM A307, Grade A hex head bolts and ASTM A563, Grade A hex head nuts. Grooved End Couplings: Carbon steel, ASTM A183 bolts and nuts, 110,000 psi minimum tensile strength. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts and ASTM A194/A194M, Grade 8M hex nuts.
Gaskets	All flanges	Water Services: 1/16-inch-thick, compressed inorganic fiber with nitrile binder, rated to 700 degrees F and 1,000 psi. Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange. Grooved Couplings: EPDM per ASTM D2000 for water and oil-free air to 230 degrees F, nitrile for oil vapor in air and oil services to 180 degrees F. NSF 61 approved for potable water service.
Thread Lubricant	2" & smaller	General Service: 100 percent virgin PTFE Teflon tape. NSF 61 Certification required

END OF SECTION

SECTION 40 27 00.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
General		Materials in contact with potable water shall conform to NSF 61 acceptance
Pipe	2-1/2" & smaller	Schedule 40S: ASTM A312/A312M, Type 316 seamless, pickled and passivated.
	3" thru 6"	Schedule 10S: ASTM A778, "as-welded" grade, Type 316L, pickled and passivated.
	8" & larger	Schedule 5S: ASTM A778, "as-welded" grade, Type 316L, pickled and passivated.
Tubing	All	ASTM A269, Type 316 stainless steel, seamless, fully annealed hydraulic tubing, 0.065-inch wall thickness minimum.
Joints	1-1/2" & smaller	Threaded or flanged at equipment as required or shown.
	2" & larger	Butt-welded or flanged at valves and equipment.
Tubing Joints	All	Flareless compression fitting
Fittings	1-1/2" & smaller	Threaded: Forged 1,000 CWP minimum, ASTM A182/A182M, Grade F316 or cast Class 150, ASTM A351/A351M, Grade CF8M/316.
	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP316L conforming to ASME B16.9 and MSS SP 43, annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" & larger	Butt-Welded: ASTM A774/A774M Grade 316L conforming to MSS SP 43, "as-welded" grade, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.

SECTION 40 27 00.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Tubing Fittings	All	Flareless Compression Type Forged: ASTM A182/A182M, Grade F316, Parker-Hannifin Ferulok, Flodar BA Series.or equal
Branch Connections	1-1/2" & smaller	Tee or reducing tee in conformance with fittings above.
	2" & larger	Butt-welding tee or reducing tee in accordance with fittings above.
Tubing Branch Connections	All	Compression type tees or reducing tees in accordance with Tubing Fittings above.
Flanges	All	Forged Stainless Steel: ASTM A182/A182M, Grade F316L, ASME B16.5 Class 150 or Class 300, slip-on, weld neck or raised face. Cast Carbon Steel: ASTM A216/A216M Grade WCA, drilled, ASME B16.5 Class 150 or Class 300 Van Stone Type with stainless steel stub ends, ASTM A240 Type 316L "as-welded grade", conforming to MSS SP 43, wall thickness same as pipe. Blind Flanges, exposed to the atmosphere and not buried nor immersed in liquid, may be either stainless steel or Class 125 ductile iron or Class 150 carbon steel with gaskets as specified herein.
Unions	2" & smaller	Threaded Forged: ASTM A182/A182M, Grade F316, 2,000-pound or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.

SECTION 40 27 00.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Bolting	All	Forged Flanges: Type 316 stainless steel, ASTM A320/A320M Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts. Van Stone Flanges: Carbon steel ASTM A307 Grade B hex head bolts and ASTM A563 Grade A hex head nuts. Provide same on mating cast iron flange on valve or equipment with flat ring gasket. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts and ASTM A194/A194M, Grade 8M hex nuts.
Gaskets	All Flanges	Flanged, Water and Sewage Service: 1/8 inch thick, unless otherwise specified, red rubber (SBR), hardness 80 (Shore A), rated to 200 degrees F, conforming to ASME B16.21, AWWA C207, and ASTM D1330, Grade 1 and Grade 2. Flanged, Hot Air and Fuel Gas Service: 1/8-inch thick, unless otherwise specified, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 300 degrees F, conforming to ASME B16.21 and ASTM D1330 Steam Grade. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange.
Thread Lubricant	2" & smaller	General Service: 100% virgin PTFE Teflon tape.

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SECTION 40 27 00.09
STAINLESS STEEL PIPE AND FITTINGS—SPECIAL SERVICE

Item	Size	Description
General		Materials in contact with potable water shall conform to NSF 61 acceptance
Pipe	All	ASTM A312/A312M Type 304 or Type 316 seamless annealed, pickled and passivated. Use Type 304L or Type 316L for welded joints.
	2" & smaller	Schedule 40S.
	2-1/2" thru 8"	Schedule 10S.
	8" & larger	Schedule 5S.
Tubing	3/4" OD & smaller	ASTM A269 Type 316 seamless, soft annealed, 0.083-inch wall thickness minimum.
Pipe Joints	3/4" & smaller	Threaded or flanged at equipment as required or shown.
	1" & 1-1/2"	Socket weld or flanged at equipment as required or shown.
	2" & larger	Butt-welded or flanged at valves and equipment as required or shown.
Tubing Joints	All	Flareless compression fitting or socket-weld.
Pipe Fittings	3/4" & smaller	Threaded Forged: ASTM A182/A182M, Grade F304 or F316, 3,000-pound WOG.
	1" and 1-1/2"	Socket Weld Forged: ASTM A182/A182M, Grade F304L or F316L, 2,000-pound WOG.
	2" & larger	Butt Welded: ASTM A403/A403M, Grade WP304L or WP316L conforming to ASME B16.9 and MSS SP 43, annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise.
Tubing Fittings	All	Flareless Compression Type Forged: ASTM A182/A182M, Grade F304 or F316, Parker-Hannifin Ferulok, Flodar BA Series.
		Socket Welded: ASTM A182/A182M, Grade F304L or F316L, Cajon, Swagelok.

SECTION 40 27 00.09
STAINLESS STEEL PIPE AND FITTINGS—SPECIAL SERVICE

Item	Size	Description
Pipe Branch Connections	3/4" & smaller	Tee or reducing tee in conformance with Fittings above.
	2" & smaller	1-1/2-Inch and Smaller Branch: Forged Sockolet or half coupling, 2,000-pound WOG ASTM A182/A182M, Grade F304L or F316L.
	2-1/2" & larger	Butt-Welded Tee or Reducing Tee: In accordance with Fittings above Forged Weldolet, 2,000-pound WOG ASTM A182/A182M, Grade F304L or F316L same inside diameter as branch pipe.
Tubing Branch Connections	All	Compression type or socket-weld tees or reducing tees in accordance with Tubing Fittings above.
Flanges	All	Forged: ASTM A182/A182M Rev C Grade F304L or F316L, Class 150 or Class 300, slip-on welding neck, 1/16-inch raised face, ASME B16.5 standard.
Unions	3/4" & smaller	Threaded Forged: ASTM A182/A182M, Grade F304 or F316, 2,000- or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.
	1" & 1-1/2"	Socket Weld Forged: ASTM A182/A182M Rev C Grade F304L or F316L, 2,000- or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.
Bolting	All	General Conditions: Type 316 stainless steel, ASTM A193/A193M, Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts. When mating flange on valve or equipment is cast iron and gasket is flat ring, provide ASTM A307 Grade B hex head bolts and ASTM A563 Grade A heavy hex nuts.
Gaskets	All Flanges	1/16-inch thick virgin Teflon or inorganic filled Teflon flat ring type for raised face flanges and full face type for flat face flanges, Garlock, Chesterton.
Thread Lubricant	2" & smaller	General Service: 100% virgin PTFE Teflon tape

SECTION 40 27 00.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

Item	Size	Description
General		Materials in contact with potable water shall conform to NSF 61 acceptance
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Pipe and fittings shall be listed by NSF for use with potable water. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One piece, molded hub type PVC flat face flange in accordance with Fittings above, 125-pound ASME B16.1 drilling
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts and ASTM A563 Grade A heavy hex head nuts.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.

SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656 and as recommended by pipe and fitting manufacturer, except solvent weld cement for PVC pipe joints in sodium hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service. Certification shall be submitted. Solvent cement and primer shall be listed by NSF for use with potable water.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

SECTION 40 27 00.11
CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

Item	Size	Description
General		Materials in contact with potable water shall conform to NSF 61 acceptance
Pipe	All	Schedule 80 CPVC: Type IV, Grade I or Class 23447-B conforming to ASTM D1784 and ASTM F441. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Pipe and fittings shall be listed by NSF for use with potable water. Threaded nipples shall be Schedule 80.
Fittings	All	Schedule to Match Pipe Above: Conforming to the requirements of ASTM F439 for socket weld type and Schedule 80 ASTM F437 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One piece, molded hub Type CPVC flat face flange in accordance with Fittings above; 125-pound ASME B16.1 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts. Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts and ASTM A563 Grade A heavy hex head nuts.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.

SECTION 40 27 00.11 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
Solvent Cement	All	All socket type joints shall be made employing primer and solvent cements that meet or exceed the requirements of ASTM F493 and primers that meet or exceed the requirements of ASTM F656 and as recommended by the pipe and fitting manufacturer, except solvent weld cement for CPVC pipe joints in sodium hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service. Certification shall be submitted. Solvent cement and primer shall be listed by NSF for use with potable water.
Thread Lubricant	All	Teflon tape.

END OF SECTION

SECTION 40 27 00.13 COPPER AND COPPER ALLOY PIPE, TUBING, AND FITTINGS	
Item	**Description**
General	Materials in contact with potable water shall conform to NSF 61 acceptance.
Tubing	Seamless, conforming to ASTM B88 as follows: ....Water (buried) Type K, soft or hard temper Water (exposed).....................Type L, hard drawn Domestic hot water................Type L, hard drawn .... Sample line service................Type L, hard drawn
Fittings	Other Services: Commercially pure wrought copper, socket joint, conforming to ASTM B75, dimensions conforming to ASME B16.22.
Flanges	Other Services: Commercially pure wrought copper, socket joint, conforming to ASTM B75, faced and drilled 150-pound ASME B16.24 standard.
Bolting	Other Services: ASTM A307, carbon steel, Grade A hex head bolts, and ASTM A563 Grade A hex head nuts.
Gaskets	1/16-inch thick nonasbestos compression type, full face, Cranite, John Manville.
Solder	Joints 2-1/2 Inch and Smaller: Wire solder (95 percent tin), conforming to ASTM B32 Alloy Grade Sn95. Do not use cored solder. Joints Larger Than 2-1/2 Inch: Wire solder, melt range approximately 440 degrees F to 660 degrees F, conforming to ASTM B32 Alloy Grade HB or HN. Do not use cored solder.

END OF SECTION

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Piping Schedule										
Service	**Legend**	**Size(s) (In.)[1]**	**Exposure**	**Piping Material**	**Specification Section**	**Joint Type**	**Lining/ Coating [2]**	**Test Pressure and Type (psig-x), x = Type indicated in Legend**	**Pipe Color and Label**	**Remarks**
AIR SCOUR	AS	ALL	EXP, SUB	SST	40 27 00	FLANGED, WELDED	Per Spec	50 – H	Per Spec	
AIR SCOUR VENT	ASV	ALL	EXP	SST	40 27 00	WELDED	Per Spec	50 – H	Per Spec	
BACKWASH WASTE WATER	BWW	ALL	EXP, SUB	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	G	Per Spec	
BACKWASH WASTE WATER	BWW	ALL	BUR	DI	33 05 01	MECH JT	Per Spec	G	None	
GAC/UV BYPASS	BYP	ALL	BUR	DI	33 05 01	MECH JT	Per Spec	50 – H	None	
CONTACTOR WASTE	CTW	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	50 – H	Per Spec	
DRAIN	DR	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	G	Per Spec	
DRAIN	DR	ALL	BUR	DI OR PVC	33 05 01	MECH JT, HU	Per Spec	G	Per Spec	
FILTER BACKWASH WATER SUPPLY	FBWS	ALL	EXP	DI OR STEEL	33 05 01	FLANGED, GRVD CPLG	Per Spec	100 – H	Per Spec	
FILTER BACKWASH WATER SUPPLY	FBWS	ALL	BUR	DI	40 27 00	MECH JT	Per Spec	100 – H	Per Spec	
FILTER EFFLUENT	FE	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	50 – H	Per Spec	

Piping Schedule										
Service	Legend	Size(s) (In.)[1]	Exposure	Piping Material	Specification Section	Joint Type	Lining/ Coating 2	Test Pressure and Type (psig-x), x = Type indicated in Legend	Pipe Color and Label	Remarks
FILTER EFFLUENT	FE	ALL	BUR, ENC	DI	40 27 00 33 05 01	MECH JT	Per Spec	50 – H	Per Spec	
FINISHED WATER SAMPLE	FW	ALL	EXP, BUR	PVC	40 27 00 33 05 01	W	None	50 – H	Per Spec	
GAC BACKWASH WATER SUPPLY	GBS	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	100 – H	Per Spec	
GAC EFFLUENT	GE	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	50 – H	Per Spec	
GAC EFFLUENT	GE	ALL	BUR	DI	33 05 01	MECH JT	Per Spec	50 – H	Per Spec	
GAC INFLUENT	GI	ALL	EXP, SUB	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	50 – H	Per Spec	
OVERFLOW	OF	ALL	BUR, SUB	DI	40 27 00	FLANGED, GRVD CPLG, MECH JT	Per Spec	G	Per Spec	
SLURRY FEED	SF	ALL	BUR, EXP, SUB	SST	40 27 00	FLANGED, GRVD CPLG, WELDED	Per Spec	100 – H	Per Spec	
SLURRY WATER SUPPLY	SWS	ALL	EXP, SUB	DI	40 27 00	FLANGED	Per Spec	150 – H	Per Spec	
UV EFFLUENT	UE	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	50 – H	Per Spec	
UV EFFLUENT	UE	ALL	BUR	DI	33 05 01	MECH JT	Per Spec	50 – H	Per Spec	

Piping Schedule

Service	Legend	Size(s) (In.)[1]	Exposure	Piping Material	Specification Section	Joint Type	Lining/ Coating[2]	Test Pressure and Type (psig-x), x = Type indicated in Legend	Pipe Color and Label	Remarks
WASTE	WS	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	G	Per Spec	
VENT	V	ALL	EXP	DI OR STEEL	40 27 00	FLANGED, GRVD CPLG	Per Spec	G	Per Spec	
CHEMICAL FEED	CF	ALL	EXP, BUR*	PVC	40 27 00	W	None	100-H	Per Spec	BUR=inside cover pipe

[1]“>” Greater Than
“<” Less Than
“<=” Less Than or Equal To
“>=” Greater Than or Equal To
“All” All Sizes

2Line and shop coating (if any) system as specified in Section 40 27 00; final coating, color code and label as specified in Section 09 90 00

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SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings.
   b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
2. American Water Works Association (AWWA):
   a. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   b. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   c. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   d. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   e. Manual M11, Steel Pipe—A Guide for Design and Installation.
3. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF): NSF 61, Drinking Water System Components—Health Effects.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).

B. Informational Submittals:

1. Coupling Harness:
   a. Details, ratings, calculations and test reports for thrust restraints relying on welded bars or rings.
   b. Weld procedure qualifications.
   c. Load proof-testing report of prototype restraint for any size coupling.

2. Basket Strainer:
   a. Manufacturer's written/printed installation instructions.
   b. Manufacturer's Certificate of Proper Installation as specified in Section 01 43 33, Manufacturers' Field Services.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools for basket strainer:

Item	Quantity
Basket	One for each strainer
Disc seals	One for each strainer
Special tools required to maintain or dismantle	One complete set

PART 2 PRODUCTS

2.01 GENERAL

A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

2.02 CONNECTORS

A. Teflon Bellows Connector:

1. Type: Two convolutions, unless otherwise shown, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ASME B16.5 standard.
3. Working Pressure Rating: 140 psi, minimum, at 120 degrees F.
4. Thrust Restraint: Limit bolts to restrain force developed by specified test pressure.
5. Manufacturers and Products:
   a. Garlock; Style 214.
   b. Resistoflex; No. R6904.
   c. Unisource Manufacturing, Inc.; Style 112.
   d. Proco Products, Inc.; Series 442.

B. Elastomer Bellows Connector:

1. Type: Fabricated spool, with single filled arch.
2. Materials: Nitrile tube and wrap-applied neoprene cover.
3. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with full elastomer face and steel retaining rings.
4. Working Pressure Rating: 140 psig, minimum, at 180 degrees F for sizes 12 inches and smaller.
5. Thrust Restraint: Control rods to limit travel of elongation and compression.
6. Manufacturers and Products:
   a. Goodall Rubber Co.; Specification E-1462.
   b. Garlock; Style 204.
   c. Unisource Manufacturing, Inc.; Style 1501.
   d. Proco Products, Inc.; Series 220.

C. Metal Bellows Connector:

1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
2. Material: Type 316 stainless steel.
3. End Connections: ANSI 150-pound carbon steel flanges.
4. Minimum Design Working Pressure: 150 psig at 750 degrees F.
5. Length: Minimum of four convolutions and minimum manufacturer recommendation for vibration isolation.
6. Manufacturers and Products:
   a. Victaulic Depend-O-Lok, Omniflex with short metal bellows.
   b. Metraflex, Model MN.

D. Flexible Metal Hose Connector:

1. Type: Close pitch, annular corrugated with single braided jacket.
2. Material: Bronze.
3. End Connections: Female copper solder joint.
4. Minimum Burst Pressure: 500 psig at 70 degrees F.
5. Length: Minimum manufacturer recommendation for vibration isolation.
6. Manufacturers:
   a. Senior Flexonics.
   b. Anamet Industrial, Inc.
   c. Unisource Manufacturing, Inc.
   d. Proco Products, Inc.

E. Closure Collar Concrete: As specified in Section 03 30 00, Cast-in-Place 03 30 01, Reinforced Concrete.

F. Quick Connect Couplings for Chemical Services:

1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
2. Materials: Glass-filled polypropylene or PVDF with EPDM, Viton-A or Teflon gaskets as recommended for the service by manufacturer.
3. End Connections: NPT threaded or flanged to match piping connections. Hose shank for chemical installations.
4. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.
5. Pressure Rating: 125 psi, minimum, at 70 degrees F.
6. Manufacturers and Products:
   a. OPW; Kamlock.
   b. Ryan Herco; 1300 Series.

2.03 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF 61.
2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
3. Couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210.
4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11, and restrained with retainer bar or ring welded to pipe end, or as shown on Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Flexible Sleeve Type Coupling:

1. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 38.
      2) Smith-Blair, Inc.; Style 411.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 253.
      2) Smith-Blair, Inc.; Style 411.

C. Bolted Split Sleeve Type Coupling: Victaulic Co., Depend-O-Lok couplings.

D. Transition Coupling for Steel Pipe:

1. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 162.
   b. Smith-Blair, Inc.; Style 413.

E. Flanged Coupling Adapter:

1. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 913.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 912.

F. Restrained Flange Adapter:

1. Pressure Rating:
   a. Minimum Working Pressure Rating: Not less than 150 psi.
   b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
   a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
   b. Products employing set screws that bear directly on pipe will not be acceptable.
3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

G. Dismantling Joints:

1. Pressure Rating:
   a. Minimum working pressure rating shall not be less than rating of the connecting flange.
   b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.
2. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 131.
   b. Viking Johnson.

H. Exposed Metallic Piping Plain End Couplings:

1. Plain end pipe couplings shall be self-restrained against hydrostatic thrust forces equal to not less than two times the working pressure rating of the coupling. Couplings shall accommodate 4 degrees angular deflection at the time of installation and subsequent to pressurization.
2. Casing, bolts, and nuts shall be Type 304 or Type 316 stainless steel. The sealing sleeve shall be EPDM or NBR elastomer as best suited for the fluid service.
3. Couplings manufacturer and products shall be Straub Couplings, Grip-L or Metal Grip, or equal.

2.04 EXPANSION JOINTS

A. Elastomer Bellows:

1. Type: Reinforced molded wide arch.
2. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with split galvanized steel retaining rings.
3. Washers: Over retaining rings to help provide leak-proof joint under test pressure.
4. Thrust Protection: Control rods to protect the bellows from overextension.
5. Bellows Arch Lining: Buna-N, nitrile, or butyl.
6. Rated Temperature: 250 degrees F.
7. Rated Deflection and Pressure:
   a. Lateral Deflection: 3/4 inch, minimum.
   b. Burst Pressure: Four times the working pressure.
   c. Compression deflection and minimum working pressure as follows:

Size (inch)	**Deflection (inch)**	**Pressure (psig)**
2-1/2 to 12	1.06	150
14	1.65	130
16 to 20	1.65	110

8. Manufacturers and Products:
   a. General Rubber Corp.; Style 1015 Maxijoint.
   b. Mercer; Flexmore Style 450.
   c. Goodall Rubber Co.; Specification E-711.
   d. Unisource Manufacturing, Inc.; Series 1500.
   e. Proco Products, Inc.; Series 251.

B. Teflon Bellows:

1. Type: Three convolutions, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ASME B16.5 standard.
3. Working Pressure Rating: 100 psig, minimum, at 120 degrees F.
4. Thrust Restraint: Limit bolts to restrain force developed by specified test pressure.
5. Manufacturers and Products:
   a. Garlock; Style 215.
   b. Resistoflex; No. R6905.
   c. Unisource Manufacturing, Inc.; Style 113,
   d. Proco Products, Inc.; Series 443.

C. Metal Bellows:

1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
2. Material: Type 316 stainless steel.
3. End Connections: ASME 150-pound carbon steel flanges.
4. Minimum Design Working Pressure: 150 psig at 750 degrees F.
5. Length: Minimum of four convolutions and minimum axial compression of 3 inches.
6. Manufacturers and Products:
   a. Victaulic Depend-O-Lok, Omniflex with long metal bellows.
   b. Metraflex, Model MN.
   c. Senior Flexonics, Free Flexing Expansion Joints.

D. Copper Pipe Expansion Compensator:

1. Material: Stainless steel bellows with female copper solder joint ends.
2. Working Pressure Rating: 175 psig, minimum.
3. Accessories: Anti-torque device to protect bellows.
4. Manufacturers and Products:
   a. Senior Flexonics; Model HB.
   b. Hyspan; Model 8510.
   c. Unisource Manufacturing, Inc.; Style EC-FFS.

E. Galvanized and Black Steel Pipe Expansion Compensator:

1. Material: All stainless steel.
2. Working Pressure Rating: 175 psig, minimum.
3. Accessories: Anti-torque device to protect bellows.
4. Manufacturers and Products:
   a. Senior Flexonics; Model H.
   b. Hyspan; Model 8503.

c. Unisource Manufacturing, Inc.; Style EC-MMT.

F. Flexible Metal Hose:

1. Type: Close pitch, annular corrugated with single braided jacket.
2. Material: Stainless steel, ASTM A276, Type 321.
3. End Connections:
   a. 3 Inches and Larger: Shop fabricated flanged ends to match mating flanges.
   b. 2-1/2 Inches and Smaller: Screwed ends with one union end.
4. Minimum Burst Pressure: 600 psig at 70 degrees F for 12 inches and smaller.
5. Length: Provide hose live-length equal to lengths shown on Drawings.
6. Manufacturer:
   a. Senior Flexonics; Series 401M.
   b. Anamet Industrial, Inc.; BWC21-1.

2.05 FLEXIBLE EXPANSION JOINTS

A. Design:

1. Ball and socket type for earth settlement compensation.
2. Joints shall be double ball assemblies rated for 15-degree minimum deflection and not less than 4 inches offset from centerline of connecting piping.
3. Assembly shall accommodate up to 4 inches of expansion in length.
4. Ductile iron conforming to AWWA C153/A21.53.
5. Rated for 350 psi.
6. Components shall be lined and coated by manufacturer with fusion-bonded epoxy on all surfaces not bearing gaskets.
7. End Connections: Flanged or mechanical joint as shown and as required by connecting pipe and fittings.
8. Joint connecting to mechanical joint shall be thrust restrained.
9. Bonding:
   a. Manufacturer shall factory install thermite welded joint bonds for assembled expansion joint.
   b. Provide 24-inch bond wires for field bonds to adjacent metallic piping.
   c. Bond wires shall be No. 2 AWG with two 12-inch-long THHN insulated No. 12 AWG wire pigtails.

B. Manufacturer and Product: EBAA Iron Sales Co.; Flex-Tend.

2.06 SEAL WATER HOSE

A. Product as specified for water hose, except 3/8 inch with male NPT ends, in 2-foot lengths.

2.07 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
    a. Body: Malleable or ductile iron.
    b. Straps: Galvanized steel.
    c. Hex Nuts and Washers: Steel.
    d. Seal: Rubber.
5. Manufacturers and Products:
    a. Smith-Blair; Series 313 or 366.
    b. Dresser; Style 91.

B. Nylon-Coated Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Materials:
    a. Body: Nylon-coated iron.
    b. Seal: Buna-N.
    c. Clamps and Nuts: Stainless steel.
4. Manufacturer: Smith-Blair; Style 315 or 317.

2.08 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch.
2. Seep Ring:
    a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.
    b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.

c. Continuously fillet weld on each side all around.
3. Factory Finish:
a. Galvanizing:
1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
2) Electroplated zinc or cadmium plating is unacceptable.
b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.

C. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer's instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
4. Manufacturer: Thunderline Corp., Link-Seal Division.

2.09 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.
4. Thrust Collars:
a. Rated for thrust load developed at 250 psi.
b. Safety Factor: 2, minimum.

c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.

5. Manufacturers:
   a. American Cast Iron Pipe Co.
   b. U.S. Pipe and Foundry Co.

B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
   a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
   b. Continuously fillet welded on each side all around.

2.10 MISCELLANEOUS SPECIALTIES

A. Strainers, Water Service, 2 Inches and Smaller:

1. Type: Bronze body, Y-pattern, 200 psi nonshock rated, with screwed gasketed bronze cap.
2. Screen: Heavy-gauge Type 304 stainless steel or monel, 20-mesh.
3. Manufacturers and Products:
   a. Armstrong International; Inc.; Model F.
   b. Mueller Steam Specialty; Model 351M.

B. Strainers, Water Service, 2-1/2 Inches and Larger:

1. Type: Cast iron or ductile iron body, Y-pattern, 175 psi nonshock rated, with flanged gasketed iron cap.
2. Screen: Heavy-gauge Type 316 stainless steel, 0.045-inch perforations.
3. Manufacturers and Products:
   a. Armstrong International, Inc.; Model A7FL 125.
   b. Mueller Steam Specialty; Model 751.

C. Strainers, Plastic Piping Systems, 4 Inches and Smaller:

1. Type: Y-pattern PVC body, 150 psi nonshock rated, with screwed PVC cap and Viton seals.
2. End Connections: Screwed or solvent weld, 2 inches and smaller. Class 150 ANSI flanged, 2-1/2 inches and larger.
3. Screen: Heavy-gauge PVC, 1/32-inch mesh, minimum 2 to 1 screen area to pipe size ratio.

4. Manufacturer: Hayward.

D. Basket Strainer:

1. Service Conditions:
   a. Material Handled: Plant final effluent (No. 3 water).
   b. Temperature of Material Handled: **[C:]** degrees F, minimum to **[D:]** degrees F, maximum.
   c. Specific Gravity of Material Handled: **[E:]**.
   d. pH Range of Material Handled: **[F:]**.
   e. Range of Total Suspended Solids: **[G:]** mg/L.
2. Strainer Capacity: **[H:]** gpm, maximum pressure drop shall not exceed **[I:]** psi at **[J:]** gpm.
3. Screen: Capable of removing material larger than **[K: 0.01 inch (250 microns)]** **[L:]** in diameter.
4. Strainer: Single chamber design of **[M: cast iron]** **[N: fabricated steel]** **[O: stainless steel]** construction with a **[P: bolted]** **[Q: quick opening]** cover.
5. Process Connections: **[R: 1]**-inch flanges faced and drilled **[S: 125]** **[T: 150]** pound ASME B16.5.
6. Strainer: Double chamber design of **[U: fabricated steel]** **[V: stainless steel]** construction.
7. Permit one basket strainer to be removed for cleaning while other basket is in operation.
8. Inlet and Outlet Valves: **[W: Three-way globe type]** **[X: Lever operated swing type valve disc]** with neoprene disc seals.
9. Baskets: **[Y: Type 304 stainless steel.]** **[Z: Type 316 stainless steel.]** **[A: Monel.]**
10. Wearing parts shall be replaceable without removing strainer from line.
11. Factory Finishing:
    a. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.
    b. **[B: Furnish manufacturer's standard [C: baked] enamel finish, color as selected.] [D: Match color as specified in pipe schedule.]**
12. Manufacturer: S.P. Kinney Engineers, Inc.

E. Water Hose:

1. Furnish **[A:]** 50-foot lengths of 1-inch and **[B:]** 50-foot lengths of 1-1/2-inch rubber hose. EPDM black cover and EPDM tube, reinforced with two textile braids. Provide each length with brass male and female NST hose thread couplings to fit hose nozzle and hose valve.
2. Rated minimum working pressure of 200 psi.

3. Manufacturers:
   a. Goodyear.
   b. Boston.

F. Hose Nozzles:

1. Furnish [**A:**] 1-inch and [**B:**] 1-1/2-inch cast brass, satin finish, nozzles with adjustable fog, straight-stream, and shut-off feature and rubber bumper. Provide nozzles with female NST hose thread.
2. Manufacturers:
   a. Croker.
   b. Elkhart.

G. Pump Seal Water Sight Flow Indicators:

1. Bronze body, 3/8-inch, horizontal, ball action with tempered glass.
2. Rated 125 psi with NPT screwed ends.
3. Operate with a minimum flow of 0.25 gpm.
4. Manufacturers and Products:
   a. Eugene Ernst Co.; Series E-57-4.
   b. Jacoby Tarbox Co.

PART 3 EXECUTION

3.01 GENERAL

A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING FLEXIBILITY PROVISIONS

A. General:

1. Thrust restraint shall be provided as specified in Section 40 27 00, Process Piping—General.
2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:

1. Install 18 inches or less from face of structures; joint may be flush with face.

D. Flexible expansion joints shall be provided to compensate for earth settlement at buried piping connections to structure wall pipes. Wrap complete joint assembly in a double layer of polyethylene encasement, as specified in Section 40 27 00, Process Piping—General.

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipe where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
   a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
   b. Clean pipe surface before placing closure collars.
   c. Wet nonmetallic pipe thoroughly prior to pouring collars.
   d. Prevent concrete from entering pipe.
   e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
   f. Make entire collar in one placement.
   g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.04 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:

1. Grooved Joint and Flanged Piping Systems: Elastomer bellows expansion joint.
2. Nonmetallic Pipe: Teflon bellows expansion joint.
3. Screwed and Soldered Piping Systems: Copper or galvanized and black steel pipe expansion compensator, as applicable.
4. Air and Water Service above 120 Degrees F: Metal bellows expansion joint.
5. Pipe Run Offset: Flexible metal hose.

C. Anchors: Install as specified in Section 40 05 15, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.05 SERVICE SADDLES

A. Ferrous Metal Piping (except stainless steel): Double-strap iron.

B. Plastic Piping: Nylon-coated iron.

3.06 COUPLINGS

A. General:

1. Install in accordance with manufacturer's written instructions.
2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
3. Do not remove pipe coating. If damaged, repair before joint is made.
4. Application:
    a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
    b. Concrete Encased Couplings: Flexible coupling.

3.07 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.

B. Product Applications Unless Shown Otherwise:

1. Nonmetallic Piping: Teflon bellows connector.
2. Copper Piping: Flexible metal hose connector.
3. Compressor and Blower Discharge: Metal bellows connector.
4. All Other Piping: Elastomer bellows connector.

C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

3.08 PIPE SLEEVES

A. Application:

1. As specified in Section 40 27 00, Process Piping—General.
2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
4. Alternatively, Molded Polyethylene Pipe Sleeve as specified may be applied.

B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.09 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
   a. Wall pipes with thrust collars.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement using coated pipe penetrations as specified in Section 09 90 00, Painting and Coating.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

3.10 MISCELLANEOUS SPECIALTIES

A. Basket Strainers:

1. Install in accordance with manufacturer's instructions.
2. Field Quality Control:
    a. Conduct test on each basket strainer.
    b. Test valves shall be tested for proper seating, travel, and operation.
3. Manufacturer's Services: Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

END OF SECTION

SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3-88, Orifice Metering of Natural Gas.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
    a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
    b. B16.44, Manually Operated Metallic Gas Valves for Use in Aboveground Piping Systems up to 5 PSI.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
    a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
    b. C504, Rubber-Seated Butterfly Valves.
    c. C508, Swing-Check Valves for Waterworks Service, 2-in. through 24-in. (50 mm Through 600 mm) NPS.
    d. C509, Resilient-Seated Gate Valves for Water Supply Service.
    e. C540, Power-Actuating Devices for Valves and Slide Gates.
    f. C550, Protective Interior Coatings for Valves and Hydrants.
    g. C606, Grooved and Shouldered Joints.
    h. C800, Underground Service Line Valves and Fittings.
6. ASTM International (ASTM):
    a. A276, Standard Specification for Stainless Steel Bars and Shapes.
    b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
    c. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
    d. B61, Standard Specification for Steam or Valve Bronze Castings.
    e. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
    f. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

g. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
h. B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
i. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
j. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
k. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
l. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
m. D1784, Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

7. Canadian Gas Association, Inc. (CGA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. FM Global (FM).
9. Food and Drug Administration (FDA).
10. International Association of Plumbing and Mechanical Officials (IAPMO).
11. Manufacturers Standardization Society (MSS):
    a. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
12. NSF International (NSF): 61, Drinking Water System Components—Health Effects.
13. Underwriters Laboratories (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
    b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
    c. Power and control wiring diagrams, including terminals and numbers.
    d. For each power actuator provided, Manufacturer's standard data sheet, with application specific features and options clearly identified.

e. Sizing calculations for open-close/throttle and modulating valves and actuators.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services for:
   a. Electric actuators; full compliance with AWWA C540.
   b. Butterfly valves; full compliance with AWWA C504.
2. Certification for compliance to NSF 61 for valves used for drinking water service.
3. Tests and inspection data.
4. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.

D. Valve ends to suit adjacent piping.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.

F. Size operators and actuators to operate valve for the full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

2.02 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139 (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

B. Valve materials in contact with or intended for drinking water service to meet the following requirements:

1. Comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
2. Coatings materials to be formulated from materials deemed acceptable to NSF61.
3. Furnish certification that product is certified as suitable for contact with drinking water by an accredited certification organization in accordance with NSF 61. Provide certification for each valve type used for drinking water service.

2.03 FACTORY FINISHING

A. Epoxy Lining and Coating:

1. Use where specified for individual valves described herein.
2. In accordance with AWWA C550 unless otherwise specified.
3. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as "fusion" or "fusion bonded" epoxy.
4. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

B. Exposed Valves:

1. In accordance with Section 09 90 00, Painting and Coating.
2. Safety isolation valves and lockout valves with handles, handwheels, or chain wheels "safety yellow."

2.04 VALVES

A. Gate Valves:

1. General:
   a. AWWA gate valves to be in full compliance with stated AWWA standard and the following requirements:
      1) Provide 2-inch operating nut and handwheel for AWWA gate valves 12 inches and smaller unless otherwise specified.
      2) Provide totally enclosed spur or bevel gear operator with indicator for AWWA gate valves 14 inches and larger unless otherwise specified.
      3) Provide Affidavit of Compliance per the applicable AWWA standard for AWWA gate valves.
      4) Mark AWWA gate valves with manufacturer's name or mark, year of valve casting, valve size, and working water pressure.
      5) Repaired AWWA gate valves shall not be submitted or supplied.
      6) AWWA C509 and AWWA C515 valves may be substituted for each other.
2. Type V130 Resilient Seated Gate Valve 3 Inches to 12 Inches:
   a. Iron body, resilient seat, bronze stem and stem nut, ANSI Class 125 flanged ends, nonrising stem, in accordance with AWWA C509, minimum design working water pressure 200 psig, full port, fusion-epoxy coated inside and outside per AWWA C550, and NSF 61 certified.
   b. Manufacturers and Products:
      1) M&H Valve.
      2) Clow.
      3) U.S. Pipe.
      4) Approved Equal.
3. Type V132 Resilient Seated Gate Valve 3 Inches to 12 Inches, for Buried Service:
   a. Iron body, resilient seat, bronze stem and stem nut, mechanical joint ends, nonrising stem, in accordance with AWWA C509, 2-inch operating nut, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550, and NSF 61 certified.
   b. Manufacturers and Products:
      1) M&H Valve.
      2) Clow.
      3) U.S. Pipe.
      4) Approved equal.

4. Type V135 Resilient Seated Ductile Iron Gate Valve 3 Inches to 36 Inches:
   a. Ductile iron body, resilient seat, bronze stem and stem nut, mechanical joint ends, nonrising stem, in accordance with AWWA C515, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550, NSF 61 certified.
   b. Manufacturers and Products:
      1) American Flow Control; Series 2500.
      2) M&H; Style 7000 and C515 Large RW Valves.
      3) Clow.
      4) US Pipe.

B. Globe Valves:

1. Type V200 Globe Valve 3 Inches and Smaller:
   a. All-bronze, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
   b. Manufacturers and Products:
      1) Stockham; Figure B-22T, NPT threaded end.
      2) Crane Co.; Figure 7TF, NPT threaded end.
      3) Milwaukee; Model 1590T, soldered ends.
      4) NIBCO; Figure S-235-Y, soldered ends.

C. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 70-100.
         b) Nibco; T-580-70.
         c) Approved Equal.
      2) Soldered:
         a) Conbraco Apollo; 70-200.
         b) Nibco; S-580-70.
         c) Approved Equal.

2. Type V320 Vee-Ball Valve 1 Inch to 16 Inches:
   a. ANSI Class 150-pound flanged ends, Type 317 stainless steel body, heat treated nickel- or hard chromium-plated Type 317 stainless steel ball, splined-type 17-4 PH stainless steel shafts, reinforced PTFE flow-ring seal, reinforced PTFE with stainless steel or Hastalloy sleeve bearings, and PTFE V-ring packing. Valve to have 300:1 rangeability and equal percentage characteristic.
   b. Manufacturers and Products:
      1) Fisher Controls: Design V150.
      2) DeZurik: VPB V-Port Ball Valve.
      3) Approved equal
3. Type V330 PVC Ball Valve 2 Inches and Smaller:
   a. Rated 150 psi at 73 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, elastomer seat, Viton or Teflon O-ring stem seals, to block flow in both directions.
   b. Manufacturers and Products:
      1) Nibco; Chemtrol Tru-Bloc.
      2) ASAHI/America; Type 21.
      3) Spears; True Union.
      4) Approved equal.

D. Butterfly Valves:

1. General:
   a. In full compliance with AWWA C504 and following requirements:
      1) Suitable for throttling operations and infrequent operation after periods of inactivity.
      2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
      3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
      4) No travel stops for disc on interior of body.
      5) Self-adjusting V-type or O-ring shaft seals.
      6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
      7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
      8) Provide linings and coatings per AWWA, unless otherwise indicated on the Drawings or specified herein.

9) Valves to be in full compliance with NSF 61. Provide NSF 61 certificate for each valve.

b. Non-AWWA butterfly valves to meet the following actuator requirements:
   1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.

2. Type V500 Butterfly Valve Water Works Service 3 Inches to 72 Inches:
   a. AWWA C504, Class 150B.
   b. Short body type, flanged ends.
   c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N rubber seat bonded or molded in body only, and stainless steel seating surface.
   d. Provide epoxy lining and coating in compliance with AWWA C550.
   e. Manufacturers and Products:
      1) Pratt; Model 2FII or Triton XR-70.
      2) DeZurik; AWWA Valve.
      3) Approved Equal.

3. Type V504 Butterfly Valve General Service 4 Inches to 48 Inches:
   a. AWWA C504, Class 150B.
   b. Mechanical joint end type.
   c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N rubber seat bonded or molded in body only, and stainless steel seating surface.
   d. Provide epoxy lining and coating in compliance with AWWA C550.
   e. Manufacturers and Products:
      1) Pratt; Groundhog.
      2) DeZurik; Buried AWWA Valve.
      3) Approved Equal.

E. Check Valves:

1. Type V600 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded or soldered ends, swing type replaceable bronze disc, rated 125-pound SWP, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-319, threaded ends.
      2) Milwaukee; Figure 509, threaded ends.
      3) Stockham; Figure B-309, soldered ends.
      4) Milwaukee; Figure 1509, soldered ends.

2. Type V608 Swing Check Valve 2 Inches to 24 Inches:
   a. AWWA C508, 125-pound flanged ends, cast-iron body, bronze body seat, bronze mounted cast-iron clapper with bronze seat, rubber facing, stainless steel hinge shaft.
   b. Valves, 2 inches through 12 inches rated 175-pound WWP and 14 inches through 24 inches rated 150-pound WWP. Valves to be fitted with adjustable outside lever and weight. Increasing-pattern body valve may be used where increased outlet piping size is shown.
   c. Manufacturers and Products:
      1) M&H Valve; Style 59, 159, or 259.
      2) Mueller Co.; No. A-2600 Series.
      3) Approved Equal.

F. Self-Regulated Automatic Valves:

1. Type V730 Pressure-Relief Valve 2 Inches and Smaller:
   a. Direct diaphragm, spring controlled, cast-iron body, spring case, nitrile seat neoprene diaphragm, stainless steel valve stem, NPT threaded ends, 200 psi rated.
   b. Opens when upstream pressure reaches a maximum set point.
   c. Size/Rating: 1 1/4 inch, maximum of 20 gpm, with inlet pressure of 150 psig. Outlet pressure set at 75 psig. As shown in the Valve Schedule.
   d. Manufacturer and Product: Fisher; 98 Series.
2. Refer to Section 33 12 16, Air And Vacuum Release Valve Assemblies for Air and Vacuum Valves.

G. Miscellaneous Valves:

1. Type V940 Solenoid Valve 1/4 Inch to 2 Inches:
   a. Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA insulation Class F, 120 volts ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4 unless otherwise indicated. Size and normal position when de-energized as indicated.
   b. Minimum operating pressure differential no greater than 5 psig, maximum operating pressure differential not less than 125 psig.
   c. Manufacturers and Products:
      1) ASCO.
      2) Skinner.
      3) Approved equal.

2.05 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
   a. For AWWA valves, operator force not to exceed the requirements of the applicable valve standard. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under any operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
   b. Operator self-locking type or equipped with self-locking device.
   c. Position indicator on quarter-turn valves.
   d. Worm and gear operators one-piece design worm-gears of gear bronze material. Worm hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Cranks on gear type operator.
   c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
   d. Valve handles to take a padlock, and wheels a chain and padlock.
3. Buried Operator:
   a. Buried service operators on valves larger than 2-1/2 inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
   b. Design buried service operators for quarter-turn valves to withstand 450 foot-pounds of input torque at the FULLY OPEN or FULLY CLOSED positions, grease packed and gasketed to withstand a submersion in water to 10 psi.
   c. Buried valves shall have extension stems, bonnets, and valve boxes.

B. Electric Motor Actuators:

1. General:
   a. Comply with latest version of AWWA C540.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
   c. Controls integral with the actuator and fully equipped as specified in AWWA C540.

d. Stem protection for rising stem valves.

2. Actuator Operation—General:
   a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
   b. Manual override handwheel.
   c. Valve position indication.
   d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in the Electric Motor Actuator Schedule.
3. Open-Close (O/C) Service:
   a. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 5 minutes.
   b. Actuator suitable for throttling operation of valve at intermediate positions.
   c. LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
      2) Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.
      3) Auxiliary contact that closes in REMOTE position.
   d. OPEN and CLOSED indicating lights.
   e. Integral reversing motor starter with built-in overload protection.
   f. Valve shall remain in last position on loss of operator power.
4. Flow Control Service:
   a. Size motors for continuous duty.
   b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
   c. HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.
      2) 4 to 20 mA dc input signal to control valve in AUTO (Remote) position.
      3) Auxiliary contact that closes in AUTO (Remote) position.
   d. Valve shall close upon loss of signal, unless otherwise indicated.
   e. OPEN and CLOSED indicating lights.
   f. AC motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
   g. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.

h. Valve position output converter that generates an isolated 4 to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.

5. Actuator Power Supply:
   a. 480 volts, three-phase, unless otherwise indicated.
   b. Control power transformer, 120-volt secondary.
   c. Externally operable power disconnect switch.
6. Enclosure:
   a. As defined in NEMA 250, Type 4, unless otherwise indicated.
   b. Contain 120-volt space heaters. to prevent condensation.
7. Limit Switch:
   a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
   b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
   c. Housed in actuator control enclosure.
8. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in the Electric Motor Actuator Schedule.
9. Manufacturers and Products:
   a. EMI.
   b. AUMA.
   c. Flowserve Limitorque.
   d. Approved equal.

2.06 ACCESSORIES

A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve2-inch and larger, bearing valve tag number shown on Valve and Electric Motor Actuator Schedule and the Self-Regulated Valve Schedule.

B. Limit Switch:

1. Factory installed NEMA 4X limit switch by actuator manufacturer.
2. SPST, rated at 5 amps, 120 volts ac.

C. T-Handled Operating Wrench:

1. Two (2) each galvanized operating wrenches, 4 feet long.
2. Manufacturers and Products:
   a. Mueller; No. A-24610.
   b. Clow No.; F-2520.
   c. Approved Equal.

D. Extension Bonnet for Valve Operator: Complete with enclosed stem, extension, support brackets, and accessories for valve and operator.

1. Manufacturers and Products:
    a. Pratt;
    b. DeZurik;
    c. Approved Equal.

E. Floor Stand:

1. Nonrising, heavy pattern, indicating type.
2. Complete with solid extension stem, coupling, handwheel, stem guide brackets, and yoke attachment. Stem length as required to connect valve operating nut and floor stand.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 316 stainless steel.
5. Manufacturers and Products:
    a. Clow;
    b. Mueller,
    c. Approved Equal.

F. Floor Box:

1. Plain type, for support of nonrising type stem.
2. Complete with solid extension stem, operating nut, and stem guide brackets. Stem length as required to extend valve operating nut to within 3 inches of finish floor.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 stainless steel.
5. Manufacturers and Products:
    a. Neenah Foundry; R 7506.
    b. Clow; No. F5690.
    c. Approved equal.

G. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
    a. Clow Corp.; Figure F-5680.
    b. Walworth Co.; Figure 804.
    c. DeZurik Corp.; Series W or LWG.
    d. Approved equal.

H. Cast-Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 5-1/4-inch ID shaft.

1. Box: Cast iron with minimum depth of 9 inches.
2. Lid: Cast iron, minimum depth 3 inches, locking type, marked WATER.
3. Extensions: Cast iron.
4. Two-piece box and lid for valves 4 inches through 12 inches, three-piece box and lid for valves larger than 12 inches with base sized for valve.
5. Valve extension stem for valves with operating nuts 3 feet or greater below finish grade.
6. Manufacturers and Products:
    a. East Jordan Iron Works; Cast-Iron Valve Boxes.
    b. Bingham & Taylor; Cast-Iron Valve Boxes.
    c. Approved equal.

I. Concrete Valve Box: Designed for traffic loads, sliding type, with minimum of 10-inch ID shaft.

1. Box: High-density, reinforced concrete, minimum depth 12 inches, cast-iron ring seat.
2. Lid: Cast iron, minimum depth 3 inches, marked WATER.
3. Extensions: Concrete.
4. Manufacturers and Products:
    a. Christy Concrete Products; G Series.
    b. BES Concrete Products; G Series.
    c. Approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer's recommendations.
2. Gate, Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Butterfly Valves:
   a. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
   b. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
   c. When installed immediately downstream of a swing check, install valve with shaft perpendicular to swing check shaft.
   d. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
4. Check Valves:
   a. Install valve in horizontal or vertical flow (up) flow piping only for liquid services.
   b. Install valve in vertical flow (up) piping only for gas services.
   c. Install swing check valve with shaft in horizontal position.

E. Install a line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Extension Stem for Operator: Where the depth of the valve operating nut is 3 feet or greater below finish grade, furnish an operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

H. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of valve.

I. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

J. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet 0 inch of finish floor. Where chains hang in normally traveled areas, use appropriate “L” type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for any discrepancies with manufacturer’s data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER’S SERVICES

A. The valve(s) as listed below require manufacturer’s field services:

1. V504.

B. Manufacturer’s Representative: Present at Site for minimum person-days listed below, travel time excluded:

1. One (1) person-days for installation assistance and inspection.
2. One person-days for functional and performance testing, adjustments, and completion of Manufacturer’s Certificate of Proper Installation.

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Process Valve Schedule.

END OF SECTION

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VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-GBS-BFV-001	GAC Contactor Backwash Pump Control Valve	V500	24	GBS	10,600	25	YES	60	460	3	FC	
FT-GBS-CV-001	GAC Contactor Backwash Pump Check Valve	V608	24	GBS	10,600	25	NO	-	-	-	-	
FT-FBS-BFV-001	Filter Backwash Pump Control Valve	V500	24	FBS	11,200	25	YES	60	460	3	FC	
FT-FBS-CV-001	Filter Backwash Pump Check Valve	V608	24	FBS	11,200	25	NO	-	-	-	-	
FT-GBS-BFV-002	Filter/GAC Pump Isolation Valve	V500	30	GBS	11,200	25	NO	-	-	-	-	
FT-GBS-BFV-003	GAC Contactor 1 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-004	GAC Contactor 2 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-005	GAC Contactor 3 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-006	GAC Contactor 4 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-007	GAC Contactor 5 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-008	GAC Contactor 6 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-009	GAC Contactor 7 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GBS-BFV-010	GAC Contactor 8 Backwash Valve	V500	30	GBS	10,600	25	YES	60	460	3	O/C	
FT-GE-BFV-001	GAC Contactor 1 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	

VALVE SCHEDULE												
Tag No.	Location	Valve Type No.	Size (inches)	Flowstream	Max. Oper. Flow (gpm)	Max. Oper. Press. (psi)	Motor Actuated	Travel Time	Voltage (V)	Phase	Service	Notes
FT-GE-BFV-002	GAC Contactor 2 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-GE-BFV-003	GAC Contactor 3 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-GE-BFV-004	GAC Contactor 4 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-GE-BFV-005	GAC Contactor 5 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-GE-BFV-006	GAC Contactor 6 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-GE-BFV-007	GAC Contactor 7 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-GE-BFV-008	GAC Contactor 8 Effluent Valve	V500	20	GE	4,400	25	YES	60	460	3	FC	
FT-CTW-BFV-001	GAC Contactor 1 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-CTW-BFV-002	GAC Contactor 2 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-CTW-BFV-003	GAC Contactor 3 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-CTW-BFV-004	GAC Contactor 4 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-CTW-BFV-005	GAC Contactor 5 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	

VALVE SCHEDULE

Tag No.	Location	Valve Type No.	Size (inches)	Flowstream	Max. Oper. Flow (gpm)	Max. Oper. Press. (psi)	Motor Actuated	Travel Time	Voltage (V)	Phase	Service	Notes
FT-CTW-BFV-006	GAC Contactor 6 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-CTW-BFV-007	GAC Contactor 7 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-CTW-BFV-008	GAC Contactor 8 Backwash to Waste Valve	V500	20	CTW	10,600	25	YES	60	460	3	FC	
FT-SWS-CV-001	Slurry Water Pump 1 Check Valve	V608	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-CV-002	Slurry Water Pump 2 Check Valve	V608	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-001	Slurry Water Pump 1 Header 1 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-002	Slurry Water Pump 1 Header 2 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-003	Slurry Water Pump 2 Header 1 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-004	Slurry Water Pump 2 Header 2 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-005	Slurry Water Header 1 Feed to Backwash Header Isolation Valve	V500	4	SWS	120	180	YES	60	460	3	O/C	

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-SWS-BFV-006	Slurry Water Header 2 Feed to Backwash Header Isolation Valve	V500	4	SWS	120	180	YES	60	460	3	O/C	
FT-SWS-BFV-007	North Slurry Water Station Header 1 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-008	North Slurry Water Station Header 2 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-009	Middle Slurry Water Station Header 1 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-010	Middle Slurry Water Station Header 2 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-011	South Slurry Water Station Header 1 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-012	South Slurry Water Station Header 2 Isolation Valve	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-013	Slurry Water Feed from Header 1 to Contactor 1	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-014	Slurry Water Feed from Header 2 to Contactor 1	V500	4	SWS	120	180	NO	-	-	-	-	

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-SWS-BFV-015	Slurry Water Feed from Header 1 to Contactor 2	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-016	Slurry Water Feed from Header 2 to Contactor 2	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-017	Slurry Water Feed from Header 1 to Contactor 3	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-018	Slurry Water Feed from Header 2 to Contactor 3	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-019	Slurry Water Feed from Header 1 to Contactor 4	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-020	Slurry Water Feed from Header 2 to Contactor 4	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-021	Slurry Water Feed from Header 1 to Contactor 5	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-022	Slurry Water Feed from Header 2 to Contactor 5	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-023	Slurry Water Feed from Header 1 to Contactor 6	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-024	Slurry Water Feed from Header 2 to Contactor 6	V500	4	SWS	120	180	NO	-	-	-	-	

VALVE SCHEDULE

Tag No.	Location	Valve Type No.	Size (inches)	Flowstream	Max. Oper. Flow (gpm)	Max. Oper. Press. (psi)	Motor Actuated	Travel Time	Voltage (V)	Phase	Service	Notes
FT-SWS-BFV-025	Slurry Water Feed from Header 1 to Contactor 7	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-026	Slurry Water Feed from Header 2 to Contactor 7	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-027	Slurry Water Feed from Header 1 to Contactor 8	V500	4	SWS	120	180	NO	-	-	-	-	
FT-SWS-BFV-028	Slurry Water Feed from Header 2 to Contactor 8	V500	4	SWS	120	180	NO	-	-	-	-	
FT-GI-BFV-001	GAC Contactor 1 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-002	GAC Contactor 2 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-003	GAC Contactor 3 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-004	GAC Contactor 4 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-005	GAC Contactor 5 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-006	GAC Contactor 6 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-007	GAC Contactor 7 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-GI-BFV-008	GAC Contactor 8 Influent in Gullet	V500	30	GI	4,400	2	YES	60	460	3	O/C	
FT-BWW-BFV-001	GAC Contactor 1 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-BWW-BFV-002	GAC Contactor 2 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-BWW-BFV-003	GAC Contactor 3 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-BWW-BFV-004	GAC Contactor 4 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-BWW-BFV-005	GAC Contactor 5 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-BWW-BFV-006	GAC Contactor 6 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-BWW-BFV-007	GAC Contactor 7 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-BWW-BFV-008	GAC Contactor 8 Backwash Waste Valve in Gullet	V500	30	BWW	10,600	4	YES	60	460	3	O/C	
FT-AS-BFV-001	GAC Contactor 1 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-002	GAC Contactor 2 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-003	GAC Contactor 3 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-AS-BFV-004	GAC Contactor 4 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-005	GAC Contactor 5 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-006	GAC Contactor 6 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-007	GAC Contactor 7 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-008	GAC Contactor 8 Air Scour Isolation Valve	V510	10	AS	1,700 CFM	11	YES	60	460	3	O/C	
FT-AS-BFV-009	Air Scour Blower Isolation Valve	V510	10	AS	1,700 CFM	11	NO	-	-	-	-	
FT-AS-BFV-010	Air Scour Blower Isolation Valve	V510	10	AS	1,700 CFM	11	NO	-	-	-	-	
FT-ASV-BFV-001	Air Scour Blower Blowoff Valve Isolation	V510	10	ASV	1,700 CFM	11	NO	-	-	-	-	
FT-ASV-BFV-002	Air Scour Blower Blowoff Valve Isolation	V510	10	ASV	1,700 CFM	11	NO	-	-	-	-	
FT-ASV-BFV-003	Air Scour Blower Blowoff Valve	V510	10	ASV	1,700 CFM	11	YES	60	460	3	FC	
FT-WS-CV-001	EQ Basin Pump 1 Check Valve	V608	18	WS	3,800	60	NO	-	-	-	-	
FT-WS-CV-002	EQ Basin Pump 2 Check Valve	V608	18	WS	3,800	60	NO	-	-	-	-	

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-WS-BFV-001	EQ Basin Pump 1 Isolation Valve	V500	18	WS	3,800	60	YES	60	460	3	O/C	
FT-WS-BFV-002	EQ Basin Pump 2 Isolation Valve	V500	18	WS	3,800	60	YES	60	460	3	O/C	
FT-GE-BFV-009	FT-UV-1 Influent Isolation Valve	V500	*	GE	15,300	10	YES	60	460	3	O/C	* Valve size will be 24" for Trojan UV system or 36" for Calgon UV System
FT-UE-BFV-001	FT-UV-1 Effluent Isolation Valve	V500	*	UE	15,300	10	YES	60	460	3	O/C	* Valve size will be 24" for Trojan UV system or 36" for Calgon UV System
FT-GE-BFV-010	FT-UV-2 Influent Isolation Valve	V500	*	GE	15,300	10	YES	60	460	3	O/C	* Valve size will be 24" for Trojan UV system or 36" for Calgon UV System
FT-UE-BFV-002	FT-UV-2 Effluent Isolation Valve	V500	*	UE	15,300	10	YES	60	460	3	O/C	* Valve size will be 24" for Trojan UV system or 36" for Calgon UV System

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-GE-BFV-011	FT-UV-3 Influent Isolation Valve	V500	*	GE	15,300	10	YES	60	460	3	O/C	* Valve size will be 24" for Trojan UV system or 36" for Calgon UV System
FT-UE-BFV-003	FT-UV-3 Effluent Isolation Valve	V500	*	UE	15,300	10	YES	60	460	3	O/C	* Valve size will be 24" for Trojan UV system or 36" for Calgon UV System
FT-UE-SV-001	FT-UV-1 Drain Valve	V940	2	D	-	10	YES	60	460	3	O/C	
FT-UE-SV-002	FT-UV-2 Drain Valve	V940	2	D	-	10	YES	60	460	3	O/C	
FT-UE-SV-003	FT-UV-3 Drain Valve	V940	2	D	-	10	YES	60	460	3	O/C	
FT-FE-BFV-001	South filters combined effluent	V500	36	FE	15,300	10	YES	60	460	3	O/C	
FT-FE-BFV-002	North filters combined effluent	V500	36	FE	15,300	10	YES	60	460	3	O/C	
FT-FE-BFV-003	South filters 1,3 & 5 combined effluent	V500	30	FE	7,700	10	NO	-	-	-	-	
FT-FE-BFV-004	South filters 2, 4 & 6 combined effluent	V500	30	FE	7,700	10	NO	-	-	-	-	
FT-BYP-BFV-001	south filters combined effluent bypass to clearwell no. 1	V500	36	BYP	15,300	10	YES	60	460	3	O/C	

VALVE SCHEDULE												
Tag No.	**Location**	**Valve Type No.**	**Size (inches)**	**Flowstream**	**Max. Oper. Flow (gpm)**	**Max. Oper. Press. (psi)**	**Motor Actuated**	**Travel Time**	**Voltage (V)**	**Phase**	**Service**	**Notes**
FT-BYP-BFV-002	North filters combined effluent bypass to clearwell no. 2	V500	36	BYP	15,300	10	YES	60	460	3	O/C	
FT-FBS-GV-001	water line from US 27 pump station to GAC pump well	V135	12	BS	4,000	100	NO	-	-	-	-	
FT-WS-GV-001	equalization basin pump discharge line	V134	24	WS	3,800	50	NO	-	-	-	-	
FT-WS-GV-002	equalization basin pump discharge line	V134	24	WS	3,800	50	NO	-	-	-	-	
FT-UE-BFV-004	combined UV effluent to clearwell no. 2	V504	36	UE	15,300	10	NO	-	-	-	-	
FT-SW-GV-001	plant supply line adjacent to main entrance driveway	V135	12	SW	3,000	150	NO	-	-	-	-	
FT-SW-GV-002	plant supply line adjacent to main entrance driveway	V135	12	SW	3,000	150	NO	-	-	-	-	
FT-SW-GV-003	service line to AT building	V135	3	SW	500	150	NO	-	-	-	-	
FT-SW-GV-004	water line to construction hydrant near lab building	V135	2	SW	400	150	NO	-	-	-	-	

VALVE SCHEDULE												
Tag No.	Location	Valve Type No.	Size (inches)	Flowstream	Max. Oper. Flow (gpm)	Max. Oper. Press. (psi)	Motor Actuated	Travel Time	Voltage (V)	Phase	Service	Notes
FT-FBS-BFV-002	AT building backwash supply yard piping to filter building	V504	30	FBS	11,200	25	NO	-	-	-	-	
FT-FBS-BFV-003	Existing backwash tank supply yard piping to filter building	V504	24	FBS	11,200	30	NO	-	-	-	-	
FT-DR-GV-001	splitter box drain valve	V130	8	UE	300	5	NO	-	-	-	-	
FT-FW-GLV-001	finished water sampling pump discharge at clearwell no. 1	V200	1 1/4	FW	20	75	NO	-	-	-	-	
FT-FW-GLV-002	finished water sampling pump discharge at clearwell no. 2	V200	1 1/4	FW	20	75	NO	-	-	-	-	
FT-FW-PRV-001	finished water sampling pump discharge at clearwell no. 1	V730	1 1/4	FW	20	75	NO	-	-	-	-	
FT-FW-PRV-002	finished water sampling pump discharge at clearwell no. 2	V730	1 1/4	FW	20	75	NO	-	-	-	-	
FT-FW-BV-001	finished water sampling pump no. 1 discharge at flow split	V300	1 1/4	FW	15	50	NO	-	-	-	-	

VALVE SCHEDULE												
Tag No.	Location	Valve Type No.	Size (inches)	Flowstream	Max. Oper. Flow (gpm)	Max. Oper. Press. (psi)	Motor Actuated	Travel Time	Voltage (V)	Phase	Service	Notes
FT-FW-BV-002	finished water sampling pump no. 1 discharge at flow split	V300	1 1/4	FW	15	50	NO	-	-	-	-	
FT-FW-BV-003	finished water sampling pump no. 2 discharge at flow split	V300	1 1/4	FW	15	50	NO	-	-	-	-	
FT-FW-BV-004	finished water sampling pump no. 2 discharge at flow split	V300	1 1/4	FW	15	50	NO	-	-	-	-	
FT-SPD-CV-001	south filter effluent valve vault sump pump discharge	V600	1 1/2	DR	100	25	NO	-	-	-	-	
FT-CF-BV-001 through -004	at chemical injector assemblies on 36" line at CW 1 inlet	V330	1	CF	5	10	NO	-	-	-	-	4 valves required
FT-CF-BV-005 through -008	at chemical injector assemblies in chem feed vault for CW 2	V330	1	CF	5	10	NO	-	-	-	-	4 valves required
FT-WS-BV-001	trench drain to eq basin isolation	V500	10	WS	500	10	NO	-	-	-	-	
FT-DR-BV-001	trench drain to storm system isolation	V500	10	DR	500	10	NO	-	-	-	-	
Note: See Legend for Tag No. format and codes.												

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VALVE TAG LEGEND FOR PROCESS VALVE SCHEDULE

VALVE TAG FORMAT:

#1	#2	#3	#4
FT	GI	BFV	001

#1 - PLANT CODE

FT	FORT THOMAS
MP	MEMORIAL PARKWAY

#2 - FLOWSTREAM CODE

AS	AIR SCOUR
ASV	AIR SCOUR VENT
BWW	BACKWASH WASTE
BYP	BYPASS
BS	BACKWASH SUPPLY
CF	CHEMICAL FEED
CTW	CONTACTOR WASTE
CW	COOLING WATER
DR	DRAIN
FBS	FILTER BACKWASH SUPPLY
FE	FILTER EFFLUENT
FW	FINISHED WATER
SF	SLURRY FEED
GBS	GAC BACKWASH SUPPLY
GE	GAC EFFLUENT
GI	GAC INFLUENT
OF	OVERFLOW
SPD	SUMP PUMP DISCHARGE
SW	SERVICE WATER
SWS	SLURRY WATER SUPPLY
UE	UV EFFLUENT
WS	WASTE

#3 - VALVE TYPE

BFV	BUTTERFLY VALVE
CV	CHECK VALVE
SV	SOLENOID VALVE
GV	GATE VALVE
BV	BALL VALVE
GLV	GLOBE VALVE

#4 - UNIQUE VALVE NUMBER

-001, -002, ETC

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SECTION 40 42 13
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C165 Standard Test Method for Measuring Compressive Properties of Thermal Insulation.
   c. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   e. C534, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
   g. C552, Specification for Cellular Glass Thermal Insulation.
   h. C585, Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
   i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   j. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   k. E96, Standard Test Methods for Water Vapor Transmission of Materials.
3. International Code Council (ICC) International Energy Conservation Code (IECC).
4. Manufacturers Standardization Society (MSS): SP-69, Pipe Hangers and Supports.
5. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's descriptive literature.

B. Informational Submittals: Maintenance information.

PART 2 PRODUCTS

2.01 PIPE INSULATION

A. Type 2—Fiberglass:

1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
2. Insulation Temperature Rating: Zero to 850 degrees F.
3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in/hr-square foot degrees F at 75 degrees F.
4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96. Furnish with no jacket if field finish system specified.
5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
6. Flame Spread Rating: Less than 25 per ASTM E84.
7. Smoke Developed Index: Less than 50 per ASTM E84.
8. Manufacturers and Products:
    a. Owens Corning Fiberglass; ASJ/SSL-11.
    b. John Manville; Micro-Lok with Jacket.
    c. Approved Equal

B. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 psi per ASTM C165.
4. Temperature Rating: Minus 290 to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in/hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.

10. Follow manufacturer's recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas or approved equal

2.02 FITTING INSULATION

A. Type 2:

1. Wired in-place premolded insulation or mitered segments, or soft fiberglass insulation inserts covered with premolded 20-mil minimum thickness PVC fitting covers.
2. Manufacturers:
   a. Manville Zeston.
   b. Speedline.
   c. Proto.
   d. Ceel-Co.

B. Type 3: Same as pipe.

2.03 INSULATION AT PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

B. Copper, Ductile Iron, and Nonmetallic Pipe: High density inserts, thickness equal to adjoining insulation, of Type 3 or other rigid insulation or manufactured pre-insulated pipe hangers and insulation shields per MSS SP-69, Table 5 at support locations. Extend inserts beyond shields.

C. Steel Pipe: Insulation saddles or high density inserts, thickness equal to adjoining insulation, of Type 3 or other rigid insulation or manufactured pre-insulated pipe hangers and insulation shields per MSS SP-69, Table 5 at support locations. Extend inserts beyond shields.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, white, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Flame Spread Rating: 25 per ASTM E84.
3. Smoke Developed Index: 50 per ASTM E84.

4. Manufacturers and Products:
   a. Knauf; Proto 1000.
   b. Johns Manville; Zeston 2000.
   c. Approved equal.

B. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, minimum 0.016 inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, consisting of 40-pound kraft paper with 1-mil thick low density polyethylene film, heat and pressure bonded to inner surface of aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
5. RPR Products; Insul-Mate.
6. Childers.
7. Pabco.

C. Type F4—Foamglass Jacketing:

1. Type 3 Insulation—Buried and Up to 1 Foot Above Grade: Jacket system to Pittsburgh Corning-Pittwrap SS, 70-mil bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, heat-sealed at overlap.

PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule in Section 40 27 00, Process Piping—General.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer's instructions and as specified herein.
2. Install insulation after piping system has been pressure tested and leaks corrected.
3. Apply insulation over clean dry surfaces.
4. Do not allow insulation to cover nameplates or code inspection stamps.
5. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
6. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
7. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
8. Personnel Protection: Install on pipes from floor to 10 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

D. Placement:

1. Slip insulation on pipe or tubing before assembly when practical to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

E. Insulation at Hangers and Supports: Insulation or insulation inserts to be continuous through hanger or support.

F. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.

G. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.

2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.03 FIELD FINISHING

A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

B. Where pipe labels or banding are specified for a piping system they shall be applied to the finished insulation and not to the pipe.

3.04 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Service and Insulation Thickness table.

END OF SECTION

Service and Insulation Thickness

Service Type	Pipe Legend	Thickness	Fluid Temperature (degrees F)*	Insulation	Finish Systems: Concealed from View	Finish Systems: Indoors Exposed	Finish Systems: Outdoors	Finish Systems: Buried
Air Scour Piping	AS	3.5-10: 1.5 12-16: 2	Ambient 0 to 200°F	Type 2	None	F3	None	None
HT–Piping requiring heat tracing.		Pipe Size: Insulation Thickness Inches:[a] 1/4-3/4: 1/2 1-3: 1 3.5-10: 1.5 12-16: 2 18-24: 2.5	Caustic soda > 70° F	Type 2 Insulate and heat trace outside lines 1' above grade. Use Type 3 insulation from 1 foot above grade and all buried installations	None	F3 below 8' except with caustic soda piping. Use F1 for caustic soda	F1	F4 on Type 3

*Use these fluid temperatures unless otherwise noted in the Piping Schedule.

Inches[a]: Based upon insulation with glass fiber per ASTM C547, outdoors with 20 mph wind with 10 percent safety and no value assigned to cladding or air space at cladding. Matches the watts per foot in Section 40 05 33, Pipe Heat Tracing

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SECTION 40 90 00
INSTRUMENTATION AND CONTROL
FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This section gives general requirements for Process Instrumentation and Control (PIC).

B. Major Work Items: Includes but is not limited to engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and training for complete PIC.

1. Process instrumentation including primary elements, transmitters, control devices, and control panels.
2. Programmable controllers.
3. Computers and networks for Human Machine Interface (HMI).
4. Applications Software: Provided by Contractor for PLCs and HMI Work related to supporting this activity includes:
    a. Early delivery of programming equipment to Engineer's office.
    b. Setup and demonstration testing of programming equipment at Engineer's office.
    c. Delivery of PLCs and HMI, equipment to staging site provided by Contractor.
    d. Demonstration testing at staging site.
    e. Assistance with onsite checkout of applications software.
    f. For additional related requirements refer to:
        1) Article Sequencing and Scheduling in this section.
    g. Staging Site: Provide for development and testing of applications software. See Section 01 50 00, Temporary Facilities and Controls, for staging site requirements.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section and other PIC subsections:

1. American National Standards Institute (ANSI).

2. ASTM International (ASTM):
   a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
   c. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   d. B32, Standard Specification for Solder Metal.
   e. B88, Standard Specification for Seamless Copper Water Tube.
3. Deutsche Industrie-Norm (DIN): VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1,000V ac and up to 1,200V dc.
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
5. The Instrument, Systems, and Automation Society (ISA):
   a. RP12.06.01, Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Instrinsic Safety.
   b. S5.1, Instrumentation Symbols and Identification.
   c. S5.4, Instrument Loop Diagrams.
   d. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
   e. TR20.00.01, Specification Forms for Process Measurement and Control Instruments, Part 1: General.
6. International Conference on Energy Conversion and Application (ICECA).
7. National Electrical Code (NEC).
8. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 1, Industrial Control and Systems General Requirements.
9. National Fire Protection Association (NFPA): 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
10. Underwriters Laboratory, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

1.03 DEFINITIONS

A. Abbreviations:

1. DCU: Distributed Control Unit.
2. FDT: Factory Demonstration Test.
3. HMI: Human-Machine Interface.

4. HVAC: Heating, Ventilating, and Air Conditioning.
5. I&C: Instrumentation and Control.
6. I/O: Input and Output.
7. O&M: Operation and Maintenance.
8. P&ID: Process and Instrument Diagram.
9. PC: Personal Computer.
10. PIC: Process Instrumentation and Control.
11. PLC: Programmable Logic Controller.
12. RTU: Remote Terminal Unit.
13. SCADA: Supervisory Control and Data Acquisition.
14. SLDC: Single Loop Digital Controller.
15. SSDT: Staging Site Demonstration Test.

B. Enclosure: Control panel, console, cabinet, or instrument housing.

C. Instructor Day: Eight hours of actual instruction time.

D. Standard Software: Software packages that are independent of Project on which they are used. Standard software includes system software, supervisory control, and data acquisition (SCADA) software.

1. System Software: Application independent (non-project specific) software developed by digital equipment manufacturers and software companies. Includes, but is not limited to, operating systems; network support, programming languages (C, C++, Visual C++, BASIC, Visual Basic, etc); Office Suites (word processor, spreadsheet, database, etc.); e-mail; security (firewall, antivirus; spam, spyware, etc.) debugging aids; and diagnostics.
2. SCADA Software: Software packages independent of specific process control project on which they are used. Includes, but is not limited to, providing configuring and run-time capability for, data acquisition (I/O driver, OPC servers, etc.), monitoring, alarming, human-machine interface, supervisory control, data collection, data retrieval, trending, report generation, control, and diagnostics.
3. Controller Programming Software: Software packages for the configuring of PLCs, RTUs, DCUs, SLDC, and fieldbus devices.

E. Application Software: Software to provide functions unique to this Project and that are not provided by standard software alone, including but not limited to:

1. Configuring databases, tables, displays, historians, reports, parameter lists, ladder logic, function block, and control strategies required to implement functions unique to this Project.
2. Programming in any programming or scripting language.

F. Rising/Falling: Define action of discrete devices about their setpoint.

1. Rising: Contacts close when an increasing process variable rises through setpoint.
2. Falling: Contacts close when a decreasing process variable falls through setpoint.

G. Signal Types:

1. Analog Signal, Current Type:
   a. 4 to 20 mA dc signals conforming to ISA S50.1.
   b. Unless otherwise indicated for specific PIC subsection components, use the following ISA S50.1 options.
      1) Transmitter Type: Number 2, two-wire.
      2) Transmitter Load Resistance Capacity: Class L.
      3) Fully isolated transmitters and receivers.
2. Analog Signal, Voltage Type: 1 to 5 volts dc within panel where common high precision dropping resistor is used.
3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.
4. Pulse Frequency Signals:
   a. Direct-current pulses whose repetition rate is linearly proportional to process variable.
   b. Pulses generated by contact closures or solid state switches.
   c. Power source less than 30V dc.
5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

1.04 SYSTEM DESCRIPTION

A. Detailed Wiring Design: Panel wiring diagrams, interconnecting wiring diagrams, and P&IDs are included in Contract Drawings and designed to completely show control panel wiring, terminations, wire numbers, interfaces with other systems, hardwired functions, interlocks, and wiring of components to be provided.

B. Design Requirements:

1. Complete detailed design of PIC components and PIC drawings
2. Provide consistent hardware and software functions for PIC. For example, provide functions in control logic, sequence controls, and display layouts in same or similar manner.

3. PIC design as shown and specified includes:
   a. Functional requirements, performance requirements, and component specifications.
   b. P&IDs, block diagrams, and network diagrams.
4. Typical drawings for installation details, control panel layouts, control panel schedules, PLC I/O module wiring, panel power, and control diagrams.

C. Use a qualified PIC System Integrator for at least the following work:

1. For PIC Equipment and Ancillaries:
   a. Completing detail design.
   b. Submittals.
   c. Equipment, enclosures, and ancillaries.
   d. Instructions, details, and recommendations to, and coordination with Contractor for Certificate of Proper Installation.
   e. Verify readiness for operation.
   f. Verify correctness of final power and signal connections (lugging and connecting).
   g. Adjusting and calibrating.
   h. Starting up.
   i. Testing and coordination of testing.
   j. Training.
   k. Assist Engineer with Functional Test Part 2 as defined in Article Field Quality Control.
2. Verify following Work not by PIC System Integrator is provided:
   a. Correct type, size, and number of signal wires with their raceways.
   b. Correct electrical power circuits and raceways.
   c. Correct size, type, and number of PIC-related pipes, valves, fittings, and tubes.
   d. Correct size, type, materials, and connections of process mechanical piping for in-line primary elements.
3. NonPIC Equipment Directly Connected to PIC Equipment:
   a. Obtain from Contractor, manufacturers' information on installation, interface, function, and adjustment.
   b. Coordinate with Contractor to allow required interface and operation with PIC.
   c. For operation and control, verify installations, interfacing signal terminations, and adjustments have been completed in accordance with manufacturer's recommendations.
   d. Test to demonstrate required interface and operation with PIC.

e. Examples of items in this category, but not limited to the following:
   1) Valve operators, position switches, and controls.
   2) Motor control centers.
   3) Adjustable speed and adjustable frequency drive systems.

f. Examples of items not in this category:
   1) Internal portions of equipment provided under Division 26, Electrical, that are not directly connected to PIC equipment.
   2) Internal portions of package system instrumentation and controls that are not directly connected to PIC equipment.

1.05 SUBMITTALS

A. General:

1. Submit proposed Submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.
2. Partial Submittals not in accordance with Project Schedule will not be accepted.
3. Submittal Format:
   a. Hard Copy: Required for all submittals.
   b. Electronic Copies: Required, unless otherwise noted for specific items.
      1) Manufacturers' Standard Documents: Adobe Acrobat PDF.
      2) Documents created specifically for Project:
         a) Text and Graphics: Microsoft Word.
         b) Lists: Microsoft Excel, unless otherwise noted for specific items.
         c) Drawings: AutoCAD.
4. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
5. Legends and Abbreviation Lists:
   a. Definition of symbols and abbreviations used; for example, engineering units, flowstreams, instruments, structures, and other process items used in nameplates, legends, data sheets, point descriptions, HMI displays, alarm/status logs, and reports.
   b. Use identical abbreviations in PIC subsections.
   c. Submit updated versions as they occur.
6. Activity Completion:
   a. Action Submittals: Completed when reviewed and approved.
   b. Informational Submittals: Completed when reviewed and found to meet conditions of the Contract.

B. Action Submittals:

1. Bill of Materials: List of required equipment.
    a. Group equipment items by enclosure and field, and within an enclosure, as follows:
        1) PIC Components: By component identification code.
        2) Other Equipment: By equipment type.
    b. Data Included:
        1) Equipment tag number.
        2) Description.
        3) Manufacturer, complete model number and all options not defined by model number.
        4) Quantity supplied.
        5) Component identification code where applicable.
        6) For panels, include panel reference number and name plate inscription.
    c. Formats: Hard copy and Microsoft Excel.
2. Catalog Cuts: I&C components, electrical devices, and mechanical devices:
    a. Catalog information, marked to identify proposed items and options.
    b. Descriptive literature.
    c. External power and signal connections.
    d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.

3. Instrument List:
    a. Engineer will provide an initial Instrument List in Microsoft Excel. Data from this may be used as starting point for creating final Instrument List and Component Data Sheets.
    b. Applicable fields to be completed include, but are not limited to:

Instrument List Characteristics	
Item	**Initially Completed By**
Tag Number	Engineer
Loop Number	Engineer
Description	Engineer
Manufacturer and complete model number	Contractor
Size and scale range	Engineer
Setpoints	Engineer

Instrument List Characteristics	
Item	**Initially Completed By**
Reference P&IDs, Electrical, Mechanical, Interconnection Drawings and Installation Details Drawings	Engineer
Instrument detail number	Engineer

c. Submit updated version of Instrument List.
d. Electronic Copies: Microsoft Excel.

4. Component Data Sheets: Data sheets for I&C components.
   a. Format:
      1) Similar to ISA TR20.00.01.
      2) Microsoft Excel, one component per data sheet.
      3) Submit proposed format for Component Data Sheets before completing data sheets for individual components.
   b. Content: Specific features and configuration data for each component, including but not limited to:
      1) Tag Number.
      2) Component type identification code and description.
      3) Location or service.
      4) Service conditions.
      5) Manufacturer and complete model number.
      6) Size and scale range.
      7) Setpoints.
      8) Materials of construction.
      9) Options included.
      10) Power requirements.
      11) Signal interfaces.
      12) Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
   c. Electronic Copies: Microsoft Excel.
5. Sizing and Selection Calculations:
   a. Primary Elements:
      1) Complete calculations plus process data used. Example for Flow Elements:
         a) Minimum and maximum values, permanent head loss, and assumptions made.
   b. Controller, Computing, and Function Generating Modules: Actual scaling factors with units and how they were computed.
   c. Electronic Copies: Microsoft Excel, one file for each group of components with identical sizing calculations.

6. Preliminary Panel Elevation Drawings: Provide prior to submitting Panel Construction Drawings:
   a. Scale Drawings: Show dimensions and location of front of panel devices.
   b. Panel Legend (Bill of Material): List front of panel devices by tag number. Include nameplate inscriptions, service legends, and annunciator inscriptions.
   c. Submit electronic copies of Drawings.
7. Panel Construction Drawings:
   a. Scale Drawings: Show dimensions and locations of panel-mounted devices, doors, louvers, subpanels, internal and external.
   b. Panel Legend (Bill of Material): List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
   c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
   d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
   e. Construction Notes: Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.
   f. Submit electronic copies of Drawings.
8. Detailed Wiring Diagrams:
   a. Refer to Drawings for Detailed Wiring Diagrams including:
      1) Panel Wiring Diagrams for discrete control and power circuits.
      2) Loop Wiring Diagrams showing individual wiring diagram for each analog or pulse frequency loop.
      3) Interconnecting Wiring Diagrams showing electrical connections between equipment, consoles, panels, terminal junction boxes, and field-mounted components.
   b. Prepare as-built redline markup of detailed wiring diagrams. Show terminal numbers on switch blocks, relays, and internal components.
   c. Submit electronic copies of Drawings.
9. Panel Wiring Diagrams:
   a. Cover wiring within a panel including, but not limited to, instrumentation, control, power, and communications, and digital networks.
   b. Objectives: For use in wiring panels, making panel connections, and future panel trouble shooting.

c. Diagram Type:
   1) Ladder diagrams where applicable in a format similar to those shown on Drawings. Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.
   2) Schematic drawings for wiring of circuits that cannot be well represented by ladder diagrams.
d. Item Identification: Identify each item with attributes listed.
   1) Wires: Wire number and color. Cable number if part of multiconductor cable.
   2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
   3) Components:
      a) Tag number, terminal numbers, and location ("FIELD", enclosure number, or MCC number).
      b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
   4) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.
   5) Relay Coils:
      a) Tag number and its function.
      b) On right side of run where coil is located, list contact location by ladder number and sheet number. Underline normally closed contacts.
   6) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
   7) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.
e. Show each circuit individually. No "typical" diagrams or "typical" wire lists will be allowed.
f. Ground wires, surge protectors, and connections.
g. Wire and Cable Names: Show names and wire color corresponding to Circuit and Raceway Schedule for circuits entering and leaving a panel. Refer to Division 26, Electrical.

10. Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each analog and discrete or equipment loop.
    a. Conform to the minimum requirements of ISA S5.4.
    b. Under Paragraph 5.3 of ISA S5.4, include the information listed under Subparagraphs 2 and 6.

c. Show loop components within a panel and identify each component, component terminals, and panel terminals.
d. If a loop connects to panels or devices not provided under this section and its subsections, such as control valves, motor control centers, package system panels, variable speed drives, include the following information:
    1) Show the first component connected to within the panel or device that is not provided under this section and its subsections.
    2) Identify the component by tag and description.
    3) Identify panel and component terminal numbers.
e. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.
f. Divide each loop diagram into areas for panel face, back-of-panel, field and PLC.
g. One Drawing Per Loop: Show each loop individually. No "typical" loop diagrams will be allowed.
h. Show:
    1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
    2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
    3) Tabular summary on each analog loop diagram:
        a) Transmitting Instruments: Output capability.
        b) Receiving Instruments: Input impedance.
        c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
        d) Total loop impedance.
        e) Reserve output capacity.
    4) Circuit and raceway schedule names.

11. Communications and Digital Networks Diagrams:
a. Scope: Includes connections to telephone system, Ethernet network, and DeviceNet.
b. Format: Network schematic diagrams for each different type of network.
c. Show:
    1) Interconnected devices, both passive and active.
    2) Device names and numbers.
    3) Terminal numbers.
    4) Communication Media: Type of cable.
    5) Connection Type: Type of connector.
    6) Node and device address numbers.
    7) Wire and cable numbers and colors.

12. Panel Power Requirements and Heat Dissipation: For control panels tabulate and summarize:
    a. Required voltages, currents, and phases(s).
    b. Maximum heat dissipations Btu per hour.
    c. Calculations.
    d. Steady State Temperature Calculations: For nonventilated panels, provide heat load calculations showing the panel estimated internal steady state temperature for ambient air temperatures of 90 degrees F.
13. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for:
    a. Pipes and Tubes: Thickness, pressure rating, and materials.
    b. Components: Valves, regulators, and filters.
    c. Connections to panel-mounted devices.
    d. Panel interface connections.
    e. Submit electronic copies of Drawings.
14. Installation Details: Include modifications or further details required and define installation of I&C components.
15. Spares, expendables, and test equipment.
16. Electronic Copies: Microsoft Excel.
    a. PLC I/O List Changes: Changes to PLC I/O List reflecting actual equipment and instrumentation provided.
        1) Mark up electronic file of latest PLC I/O List from Engineer. Highlight changed cells with yellow, new rows with red, and rows to be deleted with green.
        2) Submit marked up copies changes at 30-day intervals.
17. PLC I/O List: Submit I/O assignment and Rack/Slot/Point.
18. Shop Drawings for Changes Impacting PLC and SLDC Programming:
    a. Submit details of changes required to PLC and SLDC monitoring and control resulting from installation of alternative or upgraded process equipment and instrumentation, and other causes.
    b. Submit changes at 30-day intervals.
19. Color schedule for control panels.

C. Informational Submittals:

1. Statements of Qualification:
    a. PIC System Integrator.
    b. PIC System Integrator's site representative.
    c. Resume for each PIC System Integrator's onsite startup and testing team member (engineers, technicians, and software/configuring personnel).

2. Operation and Maintenance Data: In accordance with Section 01 78 23, Operation and Maintenance Data, and in addition the following:
   a. General:
      1) Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for PIC components.
      2) Submittal Format: Both hard copy and electronic copies for all submittals. Refer to Article Submittals, heading Submittal Format.
   b. Final versions of Legend and Abbreviation Lists.
   c. Process and Instrumentation Diagrams: Marked up copy of revised P&ID to reflect as-built PIC design.
   d. Provide the following items as defined under heading Action Submittals:
      1) Bill of materials.
      2) Catalog cuts.
      3) Instrument list.
      4) Component data sheets.
      5) Detailed Wiring Diagrams: Marked up copy of revised drawings to reflect as-built design.
         a) Panel wiring diagrams.
         b) Loop diagrams.
         c) Interconnecting wiring diagrams.
      6) Panel plumbing diagrams.
      7) Applications software documentation.
   e. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices:
      1) Content for Each O&M Manual:
         a) Table of Contents.
         b) Operations procedures.
         c) Installation requirements and procedures.
         d) Maintenance requirements and procedures.
         e) Troubleshooting procedures.
         f) Calibration procedures.
         g) Internal schematic and wiring diagrams.
         h) Component and I/O Module Calibration Sheets from field quality control calibrations.
      2) Provide PDF file will linked index to all manuals.
   f. List of spares, expendables, test equipment and tools provided.
   g. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.
3. Provide Manufacturer's Certificate of Proper Installation where specified.

4. Testing Related Submittals:
   a. Factory Demonstration Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures:
         a) Proposed test procedures, forms, and checklists.
         b) Capacity, Timing, and Simulation: Describe simulation and monitoring methods used to demonstrate compliance with capacity and timing requirements.
      3) Test Documentation: Copy of signed off test results.
   b. Staging Site Demonstration Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures: Proposed test procedures, forms, and checklists.
      3) Test Documentation: Copy of signed-off test results when tests are completed.
   c. Functional Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures: Proposed test procedures, forms, and checklists.
      3) Test Documentation:
         a) Copy of signed-off test results.
         b) Completed component calibration sheets.
   d. Performance Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures: Proposed test procedures, forms, and checklists.
      3) Test Documentation: Copy of signed-off test results.
5. Owner Training Plan: In accordance with Section 01 43 33, Manufacturers' Field Services.
6. Maintenance Service Agreement: Prior to Substantial Completion, submit service agreements signed by Owner and maintenance provider for work required under Article Maintenance Service.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. PIC System Integrator: Minimum of 10 years' experience providing, integrating, installing, and starting up similar systems as required for this Project.
2. PIC System Integrator's Site Representative: Minimum of 5 years' experience installing systems similar to PIC required for this Project.

B. PIC Coordination Meetings:

1. General: Refer to Section 01 31 19, Project Meetings, for PIC coordination meetings.
2. PIC Schedule Coordination Meeting:
   a. Timing: Following Engineer review of PIC Schedule.
   b. Purpose: Discuss Engineer's comments and resolve scheduling issues.
3. Training Coordination Meeting:
   a. Timing: Following Engineer review of preliminary training plan.
   b. Purpose:
      1) Resolve required changes to proposed training plan.
      2) Identify specific Owner personnel to attend training.

1.07 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements.

B. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.

D. Cover panels and other elements that are exposed to dusty construction environments.

1.08 SEQUENCING AND SCHEDULING

A. Refer to Section 01 31 13, Project Coordination, for Contractor's scheduling requirements for applications software testing.

B. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:

1. Shop Drawing Reviews by Engineer:
   a. Prerequisite: Engineer acceptance of Schedule of Values and Progress Schedule.
   b. Schedule: In accordance with completed schedule of Shop Drawing and Sample submittals specified in Section 01 33 00, Submittal Procedures.
2. Test Prerequisite: Associated test procedures Submittals completed.
3. Training Prerequisite: Associated training plan Submittal completed.
4. PLC and HMI Configuration Training Session 1 Prerequisite: PLC and HMI hardware and software Shop Drawings approved.
5. PLC and HMI Configuring Equipment Delivered to Engineer's office:
   a. Refer to PIC subsections for a definition of this equipment.
   b. Prerequisite: PLC and HMI Configuration Training Session 1 completed.
6. PLC and HMI Configuring Equipment Demonstration Test Prerequisite: PLC and HMI configuring equipment delivered and installed at Engineer's office.
7. PLC and HMI Applications Software Configuring by Engineer at Engineer's Office.
   a. Prerequisite: PLC and HMI configuring equipment demonstration test.
   b. Duration:**:30 days.**
8. Equipment Delivered to Staging Site: Refer to PIC subsections for a definition of this equipment.
   a. Prerequisites:
      1) PLC and HMI applications software configuring by Engineer at Engineer's office completed.
      2) FDT completed.
9. Staging Site Demonstration Test Prerequisite: PLC and HMI staging equipment delivered to staging site.
10. PLC and HMI Applications Software Configuring and Testing by Engineer:
    a. Prerequisite: Staging site demonstration test completed.
    b. Duration: 30 days.
11. PLC and HMI Shipment to Site:
    a. General Prerequisites:
       1) Approval of PIC Shop Drawings and preliminary operation and maintenance data.
       2) FDT and SSDT completed.
    b. Additional prerequisite for equipment previously shipped to Engineer's office and staging site: Completion of PLC and HMI application software configuring and testing by Engineer at Staging Site.
12. PLC and HMI Installation Prerequisite: Equipment received at Site.

13. Functional Test Part 1 Prerequisite: PLC and HMI installation complete.
14. Functional Test Part 2 Prerequisite: Functional Test Part 1 completed.
15. Performance Test Prerequisite: Functional Test Part 2 completed and facility started up.

1.09 MAINTENANCE

A. Maintenance Service Agreement:

1. Duration of 1 year, unless otherwise noted in PIC subsections.
2. Start on date of Substantial Completion.
3. Performed by factory-trained service engineers with experience on PIC systems to be maintained.
4. PIC Systems Covered: PIC components, PLC, HMI, except for Engineer provided applications software.
5. Materials and labor for preventive maintenance and monthly Site visits.
6. Materials and labor for demand maintenance with coverage 24 hours per day, 7 days per week.
7. Response Time: Service engineer shall be onsite within 4 hours of request by Owner.
8. Spare Parts: If not stocked onsite, delivered to Site within 24 hours from time of request.
9. Repair or replace components or software found to be faulty.
10. Replace and restock within 1 month onsite spare parts and expendables used for maintenance. Provide list of items used and replaced.
11. Submit records of inspection, maintenance, calibration, repair, and replacement within 2 weeks after each Site visit.

B. Telephone Support: As specified in PIC subsections.

C. Software Subscription: As specified in PIC subsections.

1.10 EXTRA MATERIALS

A. As specified in PIC subsections.

B. In computing spare parts quantities based on specified percentages, round up to nearest whole number.

C. Spare Parts:

Description	Percent of Each Type and Size Used	No Less Than
dc power supplies	20	2
Fuses	20	5
Indicating light bulb	20	4
Relays	20	3
Terminal Blocks	10	2
Surge Suppressors	10	2

D. Expendables: For following items provide manufacturer's recommended 2-year supply, unless otherwise noted.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide PIC functions shown on Drawings and required in PIC subsections for each system and loop. Furnish equipment items required in PIC subsections. Furnish materials, equipment, and software (except for Engineer provided applications software), whether indicated or not, necessary to effect required system and loop performance.

B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment, materials, and software.

1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with the General Conditions, Article 6.05 Substitutes and "Or-Equals".
2. If proposed item requires, but not limited to, different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, provide such equipment and work.

C. Like Equipment Items:

1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
2. Implement same or similar functions in same or similar manner. For example control logic, sequence controls, and display layouts.

2.02 I&C COMPONENTS

A. Specifications: Refer to Section 40 91 00, Instrumentation and Control Components, for specifications for I&C components.

B. Components for Each Loop: Major components for each loop are listed in Instrument List referenced in Article Supplements. Furnish equipment that is necessary to achieve required loop performance.

C. Control Panels: Reference Control Panel Schedule in Article Supplements.

2.03 PROGRAMMABLE LOGIC CONTROLLERS

A. Reference PLC Equipment List in Article, Supplements, and PLC components in Section 40 91 00, Instrumentation and Control Components.

2.04 FIELD BUS, NETWORK, AND HMI COMPONENTS

A. Reference PIC subsections.

2.05 SERVICE CONDITIONS

A. Standard Service Conditions: The following defines certain types of environments. PIC subsections refer to these definitions by name to specify the service conditions for individual equipment units. Design equipment for continuous operation in these environments:

1. Electrical Room, Air Conditioned:
    a. Temperature: 60 degrees F to 80 degrees F.
    b. Relative Humidity: 40 percent to 60 percent.
    c. NEC Classification: Nonhazardous.
2. Inside,:
    a. Temperature:
        1) Normal: 60 degrees F to 80 degrees F.
        2) With Up to 4-Hour HVAC System Interruptions: 40 degrees F to 105 degrees F.
    b. Relative Humidity:
        1) Normal: 10 percent (winter) to 70 percent (summer).
        2) With Up to 4-Hour HVAC System Interruption: 10 percent to 100 percent.
    c. NEC Classification: Nonhazardous.
3. Outside:
    a. Temperature: Minus 20 degrees F to 104 degrees F.
    b. Relative Humidity: 10 percent to 100 percent, rain, snow, freezing rain.

c. NEC Classification: Nonhazardous.

B. Standard Service Conditions for Panels and Consoles: Unless otherwise noted, in Instrument List and Control Panel Schedule located in Article Supplements at End of Section, design equipment for continuous operation in these environments:

1. Freestanding Panel and Consoles:
   a. Inside, Air Conditioned: NEMA 1.
   b. Inside: NEMA 12.
2. Smaller Panels and Assemblies (that are not freestanding):
   a. Inside,: NEMA 12.
   b. All Other Locations: NEMA 4X.
3. Field Elements: Outside.

C. Special Environmental Requirements: Design following panels for continuous operation in environments listed.

2.06 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on enclosure face.

1. Location and Inscription: As shown on Drawings.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 1/2-inch-high, white on black background, unless otherwise noted.

B. Component Nameplates, Panel Face: Component identification located on panel face under or near component.

1. Location and Inscription: As shown on panel drawing.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

C. Component Nameplates, Back of Panel: Component identification located on or near component inside of enclosure.

1. Inscription: Component tag number.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.

1. Inscription:
    a. Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
    b. Refer to table under Paragraph Standard Light Colors and Inscriptions.
    c. Refer to P&IDs on Drawings.
2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
3. Letters: Black on gray or white background.

E. Service Legends: Component identification nameplate located on face of component.

1. Inscription: As shown on panel drawing.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

F. Nametags: Component identification for field devices.

1. Inscription: Component tag number.
2. Materials: 16-gauge, Type 304 stainless steel.
3. Letters: 3/16-inch-high, imposed.
4. Mounting: Affix to component with 16-guage or 18-gauge stainless steel wire or stainless steel screws.

2.07 MECHANICAL SYSTEM COMPONENTS

A. Reference Section 40 91 00, Instrumentation and Control Components.

2.08 FUNCTIONAL REQUIREMENTS FOR CONTROL LOOPS

A. Shown on Drawings, in panel control diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.

B. Supplemented by Loop Specifications that describe requirements not obvious on P&IDs or panel control diagrams.

C. Supplemented by standard functional requirements in PIC subsections.

2.09 ELECTRICAL REQUIREMENTS

A. Electrical Raceways: As specified in Section 26 05 33, Raceway and Boxes.

B. Wiring External to PIC Equipment:

1. Special Control and Communications Cable: Provided by PIC System Integrator as noted in Component Specifications and PIC subsections.
2. Other Wiring and Cable: As specified in Section 26 05 05, Conductors.

C. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

D. Wires within Enclosures:

1. ac Circuits:
    a. Type: 600-volt, Type MTW stranded copper.
    b. Size: For current to be carried, but not less than No. 18 AWG.
2. Analog Signal Circuits:
    a. Type: 600-volt stranded copper, twisted shielded pairs or triad with a 100 percent, aluminum-polyester shield, rated 60 degrees C.
    b. Panels with Circuits Less Than 600 volts: Rated at 600 volts. Belden No. 18 AWG Type 9341, Triad Beldon No. 1121A.
    c. Size: No. 18 AWG, minimum.
3. Other dc Circuits.
    a. Type: 600-volt, Type MTW stranded copper.
    b. Size: For current carried, but not less than No. 18 AWG.
4. Special Signal Circuits: Use manufacturer's standard cables.
5. Wire Identification: Numbered and tagged at each termination.
    a. Wire Tags: Machine printed, heat shrink.
    b. Manufacturers:
        1) Brady Perma Sleev.
        2) Tyco Electronics.

E. Terminate and identify wires entering or leaving enclosures as follows:

1. Analog and discrete signal, terminate at numbered terminal blocks.
2. Special signals terminated using manufacturer's standard connectors.
3. Identify wiring in accordance with requirements in Section 26 05 05, Conductors.

F. Terminal Blocks for Enclosures:

1. Quantity:
   a. Accommodate present and spare indicated needs.
   b. Wire spare PLC I/O points to terminal blocks.
   c. One wire per terminal for field wires entering enclosures.
   d. Maximum of two wires per terminal for No. 18 AWG wire for internal enclosure wiring.
   e. Spare Terminals: 20 percent of connected terminals, but not less than 5 per terminal block, unless otherwise shown on Drawings.
2. Terminal Block Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Article Electrical Components.

G. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections.
2. Ground this ground bus at a common signal ground point in accordance with National Electrical Code requirements.
3. Single Point Ground for Each Analog Loop:
   a. Locate signal ground at dc power supply for loop.
   b. Use to ground wire shields for loop.
   c. Group and ground wire shields in following locations:
4. Ground terminal block rails to ground bus.

H. Analog Signal Isolators:

1. Furnish signal isolation for analog signals that are sent from one enclosure to another.
2. Do not wire in series instruments on different panels, cabinets, or enclosures.

I. Electrical Transient Protection:

1. General:
   a. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
   b. Surge suppressors are not shown for external analog transmitters. Determine quantity and location, and show in Shop Drawings. Refer to example wiring in installation details in Drawings.

c. Provide, install, coordinate, and inspect grounding of surge suppressors at:
    1) Connection of ac power to PIC equipment including panels, consoles assembles, and field-mounted analog transmitters and receivers.
    2) At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.

2. Surge Suppressor Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Surge Suppressors.
3. Installation and Grounding of Suppressors:
    a. As shown. See Surge Suppressor Installation Details.
    b. Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.

2.10 PANEL FABRICATION

A. General:

1. Nominal Panel Dimensions: As shown on Drawings.
2. Instrument Arrangements: As shown on Drawings.
3. Panel Component Schedule: Refer to Control Panel Schedule in Article Supplements which provides a list by local control panel of major panel-mounted components for each panel. In case of a conflict between this list and Instrument List, Instrument List takes precedence. In case of a conflict between Panel Component Schedule and P&IDs, P&IDs take precedence.
4. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), state and local codes, and applicable sections of NEMA, ANSI, UL, and ICECA.
5. Fabricate panels, install instruments and wire, and plumb at PIC System Integrator's facility. No fabrication other than correction of minor defects or minor transit damage permitted onsite.
6. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.
7. Electrical Work: In accordance with the applicable requirements of Division 26, Electrical.

B. Temperature Control:

1. Freestanding Panels:
    a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel and on panel.

b. Ventilated Panels:
   1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel and on panel.
   2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
   3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
   4) Louver Construction: Stamped sheet metal.
   5) Ventilation Fans:
      a) Furnish where required to provide adequate cooling.
      b) Create positive internal pressure within panel.
      c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
   6) Air Filters: Washable aluminum, Hoffman Series A-FLT.

2. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel and on panel face.
3. Space Heaters:
   a. Thermostatically controlled to maintain internal panel temperatures above dewpoint.
   b. Refer to Control Panel Schedule in Article Supplements.

C. Freestanding Panel Construction:

1. Materials:
   a. Sheet steel, unless otherwise shown on Drawings.
   b. Minimum Thickness: 10-gauge, unless otherwise noted.
2. Panel Front:
   a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
   b. No seams or bolt heads visible when viewed from front.
   c. Panel Cutouts: Smoothly finished with rounded edges.
   d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.
3. Internal Framework:
   a. Structural steel for instrument support and panel bracing.
   b. Permit panel lifting without racking or distortion.
4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
5. Adjacent Panels: Securely bolted together so front faces are parallel.
6. Door:
   a. Full height, fully gasketed access door where shown on Drawings.
   b. Latch: Three-point, Southco Type 44.

c. Handle: "D" ring, foldable type.
d. Hinges: Full-length, continuous, piano-type, steel hinges with stainless steel pins.
e. Rear Access: Extend no further than 24 inches beyond panel when opened to 90-degree position.
f. Front and Side Access Doors: As shown on Drawings.

D. Nonfreestanding Panel Construction:

1. Based on environmental design requirements and referenced in Article Environmental Requirements, provide the following unless otherwise noted in Control Panel Schedule in Article Supplements:
   a. Panels listed as inside, air conditioned:
      1) Enclosure Type: NEMA 12.
      2) Materials: Steel.
   b. Other Panels:
      1) Enclosure Type: NEMA 4X.
      2) Materials: Type 316 stainless steel or Plastic.
2. Metal Thickness: 14-gauge, minimum.
3. Doors:
   a. Rubber-gasketed with continuous hinge.
   b. Stainless steel lockable quick-release clamps.
4. Manufacturers:
      1) Hoffman Engineering Co.
      2) H. F. Cox.

E. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels:

1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

F. Control Panel Electrical:

1. Power Distribution within Panels:
   a. Feeder Circuits:
      1) One or more 120V ac, 60-Hz feeder circuits as shown on Drawings.
      2) Make provisions for feeder circuit conduit entry.
      3) Furnish terminal block for termination of wires.
   b. Power Panel: Furnish main circuit breaker and circuit breaker on each individual branch circuit distributed from power panel.
      1) Locate to provide clear view of and access to breakers when door is open.

2) Breaker Sizes: Coordinate such that fault in branch circuit will blow only branch breaker, but not trip main breaker.
    a) Branch Circuit Breakers: 15 amps at 250V ac.
3) Breaker Manufacturers and Products: Refer to Division 26.

c. Circuit Wiring: P&IDs and Control Diagrams on Drawings show detailed wiring diagrams that use the following rules for circuit wiring:
    1) Devices on Single Circuit: 20, maximum.
    2) Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
    3) Branch Circuit Loading: 12 amperes continuous, maximum.
    4) Panel Lighting and Service Outlets: Put on separate 15 amp, 120V ac branch circuit.
    5) Provide 120V ac plugmold for panel components with line cords.

2. Signal Distribution:
    a. Signal Wiring: Separate analog signal cables from power and control within a panel and cross at right angles where necessary.
    b. Within Panels: 4 to 20 mA dc signals may be distributed as 1V dc to 5V dc.
    c. Outside Panels: Isolated 4 to 20 mA dc only.
    d. Signal Wiring: Twisted shielded pairs.
    e. RTD and Thermocouple Extension Cable:
        1) Continuous field to panel with no intermediate junction boxes or terminations.
        2) RTDs in motor windings are considered a 600-volt circuit.
        3) Terminate thermocouple extension wire directly to loop instrument.
3. Signal Switching:
    a. Use dry circuit type relays or switches.
    b. No interruption of 4 to 20 mA loops during switching.
    c. Switching Transients in Associated Signal Circuit:
        1) 4 to 20 mA dc Signals: 0.2 mA, maximum.
        2) 1V dc to 5V dc Signals: 0.05V, maximum.
4. Relay Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Article Electrical Components.
5. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.
6. Internal Panel Lights for Freestanding Panels:
    a. Type: Switched 100-watt incandescent back-of-panel lights.
    b. Quantity: One light for every 4 feet of panel width.
    c. Mounting: Inside and in the top of back-of-panel area.

d. Protective metal shield for lights.

7. Service Outlets for Freestanding Panels:
   a. Type: Three-wire, 120-volt, 15-ampere, GFCI GFCI duplex receptacles.
   b. Quantity:
      1) Panels 4 Feet Wide and Smaller: One.
      2) Panels Larger than 4 Feet Wide: One for every 4 feet of panel width, two minimum per panel.
   c. Mounting: Evenly spaced along back-of-panel area.
8. Internal Panel Lights and Service Outlets for Smaller Panels:
   a. Internal Panel Light: Switched 100-watt incandescent light.
   b. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:
   c. Required for panels. Refer to Control Panel Schedule in Article Supplements.
9. Standard Pushbutton Colors and Inscriptions:
   a. Use following unless otherwise noted in individual Loop Specifications:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

   b. Lettering Color:
      1) Black on white and yellow buttons.
      2) White on black, red, and green buttons.

10. Standard Light Colors and Inscriptions:
    a. Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in individual Loop Specifications:

Tag Function	Inscription(s)	Color
ON	ON	Green
OFF	OFF	Red
OPEN	OPEN	Green
CLOSED	CLOSED	Red
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow

    b. Lettering Color:
        1) Black on white and amber lenses.
        2) White on red and green lenses.

G. PIC Enclosure Internal Wiring:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Provide abrasion protection for wire bundles that pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
    a. Locking-fork-tongue or ring-tongue lugs.
    b. Use manufacturer's recommended tool with required sized anvil to make crimp lug terminations.
    c. Wires terminated in a crimp lug, maximum of one.
    d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
    a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.

   b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Duct Fill: Do not exceed manufacturer's recommendations.
12. Conductors Carrying Foreign Voltages within a Panel:
    a. Route foreign voltage conductors into panel and land on a circuit blade disconnect type terminal block.
    b. Use wire with pink insulation to identify foreign voltage circuits within panel from terminal block on. Do not use wires with pink insulation for any other purpose.
13. Harness Wiring:
    a. 120V ac: No. 14 AWG, MTW.
    b. 24V dc: No. 16 AWG, MTW where individual conductors are used and Type TC shielded tray cable where shielded wire is used.
14. Panelwork:
    a. No exposed connections.
    b. Allow adjustments to equipment to be made without exposing these terminals.
    c. For power and control wiring operating above 80V ac or dc use covered channels or EMT raceways separate from low voltage signal circuits.
15. Plastic Wire Ducts Color:
    a. 120V ac: White.
    b. 24V dc: Gray.
    c. Communications Cables and Fiber Optic Jumpers: Orange.
16. Provide a communications plastic wire duct for communications cables and fiber optic cables between the communications devices in control panel and communications raceways. Design plastic wire duct design to take into account the minimum bending radius of the communications cable.
17. Make plastic wire ducts the same depth.
18. Provide a minimum of 1-1/2 inches between plastic wire ducts and terminal blocks.

H. Control Relay Arrangement: Install control relays associated with specific loops in same panel section as corresponding terminal blocks or side panels. Provide 20 percent space for future relays. Locate spare space in same sections as spare terminal blocks.

I. Factory Finishing:

1. Furnish materials and equipment with manufacturer's standard finish system in accordance with Section 09 90 00, Painting and Coating.
2. Use specific color if indicated. Otherwise use manufacturer's standard finish color, or light gray if manufacturer has no standard color.
3. Stainless Steel and Aluminum: Not painted.
4. Nonmetallic Panels: Not painted.
5. Steel Panels:
   a. Sand panel and remove mill scale, rust, grease, and oil.
   b. Fill imperfections and sand smooth.
   c. Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
   d. Sand surfaces lightly between coats.
   e. Dry Film Thickness: 3 mils, minimum.
   f. Color: Manufacturer's standard.

2.11 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsules:

1. Areas Where Required: Refer to Part 3, Article Protection.
2. Manufacturers and Products:
   a. Northern Instruments; Model Zerust VC.
   b. Hoffmann Engineering; Model A-HCl.

2.12 SOURCE QUALITY CONTROL

A. General:

1. Engineer may actively participate in many of the tests.
2. Engineer reserves right to test or retest specified functions.
3. Engineer's decision will be final regarding acceptability and completeness of testing.
4. Procedures, Forms, and Checklists:
   a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
   b. Describe each test item to be performed.

c. Have space after each test item description for sign off by appropriate party after satisfactory completion.

5. Required Test Documentation: Test procedures, forms, and checklists signed by Engineer and Contractor.
6. Conducting Tests:
   a. Provide special testing materials and equipment.
   b. Wherever possible, perform tests using actual process variables, equipment, and data.
   c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
   d. Define simulation techniques in test procedures.
   e. Test Format: Cause and effect.
      1) Person conducting test initiates an input (cause).
      2) Specific test requirement is satisfied if correct result (effect), occurs.
   f. For PIC systems for which Engineer provides applications software, provide sufficient temporary software configuring to allow FDT and SSDT testing of these subsystems.

B. Unwitnessed Factory Test:

1. Scope: Inspect and test PIC to ensure it is operational, ready for FDT.
2. Location: PIC System Integrator's facility.
3. Integrated Test:
   a. Interconnect and test PIC, except for primary elements and smaller panels.
   b. Exercise and test functions.
   c. Provide stand-alone testing of smaller panels.
   d. Simulate inputs and outputs for primary elements, final control elements, and panels excluded from test.

C. Factory Demonstration Tests (FDT):

1. Notify Engineer of test schedule 4 weeks prior to start of test.
2. Scope:
   a. Test entire PIC, with exception of primary elements, final control elements, and certain smaller panels, to demonstrate it is operational.
   b. Refer to Control Panel Schedule in Article Supplements for list of panels for which FDT is required.
3. Location: PIC System Integrator's facility.
4. Correctness of wiring from panel field terminals to PLC system input/output points and to panel components.
   a. Simulate each discrete signal at terminal strip.
   b. Simulate correctness of each analog signal using current source.

5. Operation of communications between PLCs and remote I/O and between PLCs and computers.
6. Operation of communications between the PLC system, single loop controllers (SLC).
7. Loop-Specific Functions: Demonstrate functions shown on P&IDs and control diagrams:
   a. One of each type function; for example, if there are filter backwash sequence control for several identical filters, demonstrate controls for one filter.
   b. One of each type of function in each panel; for example, but not limited to annunciator operation, controller operation, and recorder operation.
   c. All required and shown functions for 10 percent of loops.
8. Nonloop-Specific Functions:
   a. Capacity: Demonstrate that PIC systems have required spare capacity for expansion. Include tests for both storage capacity and processing capacity.
   b. Timing: Include tests for timing requirements.
   c. Diagnostics: Demonstrate online and offline diagnostic tests and procedures.
9. Correct deficiencies found and complete prior to shipment to Site.
10. Failed Tests:
    a. Repeat and witnessed by Engineer.
    b. With approval of Engineer, certain tests may be conducted by PIC System Integrator and witnessed by Engineer as part of Functional Test.
11. Make following documentation available to Engineer at test site both before and during FDT:
    a. Drawings, Specifications, Addenda, and Change Orders.
    b. Master copy of FDT procedures.
    c. List of equipment to be tested including make, model, and serial number.
    d. Approved hardware Shop Drawings for equipment being tested.
    e. Approved preliminary software documentation Submittal.
12. Daily Schedule for FDT:
    a. Begin each day with meeting to review day's test schedule.
    b. End each day with each meeting to review day's test results and to review or revise next day's test schedule.

D. Staging Site Demonstration Test (SSDT):

1. Scope: Demonstrate that the specified PIC equipment and standard software has been properly installed at staging site and is ready for applications software development by Engineer.

2. Refer to PIC subsections for additional details.

2.13 MAINTENANCE OF PROGRAMMING EQUIPMENT

A. Provide for maintenance of programming equipment while at Engineer's office. Repair or replace failed equipment within 2 days of notice by Engineer.

PART 3 EXECUTION

3.01 EXAMINATION

A. For equipment not provided by PIC System Integrator, but that directly interfaces with PIC, verify the following conditions:

1. Proper installation.
2. Calibration and adjustment of positioners and I/P transducers.
3. Correct control action.
4. Switch settings and dead bands.
5. Opening and closing speeds and travel stops.
6. Input and output signals.

3.02 INSTALLATION

A. Material and Equipment Installation: Follow manufacturers' installation instructions, unless otherwise indicated or directed by Engineer.

B. Wiring connected to PIC components and assemblies, including power wiring in accordance with requirements in Section 26 05 05, Conductors.

C. Electrical Raceways: As specified in Section 26 05 33, Raceway and Boxes.

D. Mechanical Systems:

1. Copper and Stainless Steel Tubing Support: Continuously supported by aluminum tubing raceway system.
2. Plastic Tubing Support: Except as shown on Drawings, provide continuous support in conduit or by aluminum tubing raceway system.
3. Install conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.
4. Tubing and Conduit Bends:
    a. Tool-formed without flattening, and of same radius.
    b. Bend Radius: Equal to or larger than conduit and tubing manufacturer's recommended minimum bend radius.

c. Slope instrument connection tubing in accordance with installation details.
d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
g. Blow debris from inside of tubing.
h. Make up and install fittings in accordance with manufacturer's recommendations. Verify make up of tube fittings with manufacturer's inspection gauge.
i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
j. Run tubing to allow but not limited to, clear access to doors, controls and control panels; and to allow for easy removal of equipment.
k. Provide separate support for components in tubing runs.
l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
m. Keep tubing and conduit runs at least 12 inches from hot pipes.
n. Locate and install tubing raceways in accordance with manufacturer's recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
o. Securely attach tubing raceways to building structural members.

5. Enclosure Lifting Rings: Remove rings following installation and plug holes.

E. Field Finishing: Refer to Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. General:

1. Coordinate PIC testing with Owner and affected Subcontractors.
2. Notify Engineer of Performance Test schedule 4 weeks prior to start of test.
3. Engineer may actively participate in tests.
4. Engineer reserves right to test or retest specified functions.
5. Engineer's decision will be final regarding acceptability and completeness of testing.

B. Onsite Supervision:

1. Require PIC System Integrator to observe PIC equipment installation to extent required in order to provide Certificates of Proper Installation.
2. Require PIC site representative to supervise and coordinate onsite PIC activities.
3. Require PIC site representative to be onsite while onsite work covered by this section and PIC subsystems is in progress.

C. Testing Sequence:

1. Provide Functional Tests and Performance Tests for facilities as required to support staged construction and startup of plant.
2. Refer to article Sequence of Work under Section 01 31 13, Project Coordination, for a definition of project milestones.
3. Refer to Section 01 91 14, Equipment Testing and Facility Startup, for overall testing requirements.
4. Completion: When tests (except Functional Test) have been completed and required test documentation has been accepted.

D. Testing:

1. Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PIC equipment is ready for operation. Divide Functional Test for each facility into two parts.
2. Functional Test Part 1: Performed by PIC System Integrator to test and document PIC, excluding Engineer provided applications software, is ready for operation. For PIC Subsystems for which Engineer provides applications software, provide sufficient temporary software configuring to allow testing of these subsystems.
   a. Loop/Component Inspections and Tests:
      1) These inspections and tests do not require witnessing.
      2) Check PIC for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
      3) Provide space on forms for signoff by PIC System Integrator.
      4) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
         a) Project name.
         b) Loop number.
         c) Tag number for each component.

- d) Checkoffs/Signoffs for Each Component:
  - (1) Tag/identification.
  - (2) Installation.
  - (3) Termination wiring.
  - (4) Termination tubing.
  - (5) Calibration/adjustment.
- e) Checkoffs/Signoffs for the Loop:
  - (1) Panel interface terminations.
  - (2) I/O interface terminations with PLCs.
- f) I/O Signals for PLCs are Operational: Received/sent, processed, adjusted.
- g) Total loop operational.
- h) Space for comments.

5) Component calibration sheet for each active I&C component (except simple hand switches, lights, gauges, and similar items) and each PLCs, I/O module and include the following:
- a) Project name.
- b) Loop number.
- c) Component tag number or I/O module number.
- d) Component code number for I&C elements.
- e) Manufacturer for I&C elements.
- f) Model number/serial number for I&C elements.
- g) Summary of Functional Requirements; For Example:
  - (1) Indicators and recorders, scale and chart ranges.
  - (2) Transmitters/converters, input and output ranges.
  - (3) Computing elements' function.
  - (4) Controllers, action (direct/reverse) and control modes (P, I, D).
  - (5) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
  - (6) I/O Modules: Input or output.
- h) Calibrations, for example, but not limited to:
  - (1) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
  - (2) Discrete Devices: Actual trip points and reset points.
  - (3) Controllers: Mode settings (P&ID).
  - (4) I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
  - (5) Space for comments.

b. Maintain loop status reports, valve adjustment sheets, and component calibration sheets at Site, and make them available to Engineer at all times.
c. Engineer reviews loop status sheets and component calibration sheets and spot-check their entries periodically, and upon completion of Preparation for Testing. Correct deficiencies found.
d. FDT-Repeat:
    1) Repeat FDT onsite with installed PIC equipment and software.
    2) As listed in PIC subsections, certain portions of FDT may not require retesting.
    3) Use FDT test procedures as basis for this test.
    4) In general, this test shall not require witnessing. However, portions of this test, as identified by Engineer during original FDT shall be witnessed.
e. Forms: See Loop Status Report, Instrument Calibration Sheet, and I&C Valve Adjustment Sheet referenced in Article Supplements.

3. Functional Test Part 2: Combined effort between Contractor, PIC System Integrator, and Engineer to confirm PIC, including applications software, is ready for operation.
    a. Prerequisite: Completion of Functional Test Part 1.
    b. Joint test with Engineer. Repeat of Engineer's SSDT application software tests, except using real field sensors and equipment. Plant interlocking and communications with PLCs, FOCS, HMI tested on loop-by-loop basis.
    c. Test procedures provided by Engineer based on Functional Test Part 1 and on SSDT application software tests.
    d. Completed when Functional Test has been conducted and Engineer has spot-checked associated test forms and checklists in field.
4. Functional Test:
    a. Scope: Confirm PIC, including applications software, is ready for operation.
    b. Refer to PIC subsections for additional requirements.
    c. Completed when Functional Test has been conducted and Engineer has spot-checked associated test forms and checklists in field.
5. Required Test Documentation: Test procedures, forms, and checklists. Signed by Engineer and Contractor except for Functional Test items signed only by Contractor.

E. Performance Test During and After Facility Startup:

1. Once a facility's Functional Test has been completed and that facility has been started up, perform a witnessed Performance Test on associated PIC equipment to demonstrate that it is operating as required by Contract Documents. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.
2. Loop-specific and nonloop-specific tests same as required for FDT except that entire installed PIC tested using actual process variables and functions demonstrated.
3. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
4. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
5. Make updated versions of documentation required for Performance Test available to Engineer at Site, both before and during tests.
6. Make O&M data available to Engineer at Site both before and during testing.
7. Follow daily schedule required for FDT.
8. Determination of Ready for Operation: When Functional Test has been completed.
9. Refer to examples of Performance Test procedures and forms in Article Supplements.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: As required by each PIC subsection.

3.05 TRAINING

A. General:

1. Provide an integrated training program for Owner's personnel.
2. Perform training to meet specific needs of Owner's personnel.
3. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
4. Provide instruction on one working shift(s) as needed to accommodate the Owner's personnel schedule.
5. Owner reserves the right to reuse videotapes of training sessions.

B. Operations and Maintenance Training:

1. General:
   a. Refer to specific requirements specified in PIC Subsections.
   b. Include review of O&M data and survey of spares, expendables, and test equipment.
   c. Use equipment similar to that provided.
   d. Unless otherwise specified in PIC subsections, provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics, instrumentation, or digital systems.
2. Operations Training: For Owner's operations personnel on operation of I&C components.
   a. Training Session Duration: One instructor days.
   b. Number of Training Sessions: One.
   c. Location: Project Site.
   d. Course Objective: Develop skills needed to use I&C components and functions to monitor and control the plant on a day-to-day basis.
   e. Content: Conduct training on loop-by-loop basis.
      1) Loop Functions: Understanding of loop functions, including interlocks for each loop.
      2) Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
      3) Interfaces with PIC subsystems.
3. Maintenance Training:
   a. Training Session Duration: One instructor days.
   b. Number of Training Sessions: One.
   c. Location: Project Site.
   d. Course Objective: Develop skills needed for routine maintenance of PIC.
   e. Content: Provide training for each type of component and function provided.
      1) Loop Functions: Understanding details of each loop and how they function.
      2) Component calibration.
      3) Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
      4) Troubleshooting and diagnosis for equipment and software.
      5) Replacing lamps, chart paper, and fuses.
      6) I&C components removal and replacement.
      7) Periodic preventive maintenance.

3.06 CLEANING

A. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.07 PROTECTION

A. Use corrosion-inhibiting vapor capsules in enclosures to protect electrical, instrumentation, and control devices, including spare parts, from corrosion.

B. Periodically replace capsules based on capsule manufacturer's recommendations.

3.08 SUPPLEMENTS

A. Supplements listed below, follows "End of Section," are part of this Specification.

1. Instrument List.
2. PLC Equipment List.
3. PLC Input/Output List.
4. Control Panel Schedule.
5. Preparation for Testing and Functional Test Forms:
    a. Loop Status Report: Each sheet shows status of instruments on a loop. Also, gives functional description for loop.
    b. Instrument Calibration Sheet: Shows details on each instrument (except simple hand switches, lights, and similar items).
    c. I&C Valve Adjustment Sheet: Shows details for installation, adjustment, and calibration of a given valve.
6. Performance Test Sheet: Describe Performance Test for a given loop.
    a. List requirements of the loop.
    b. Briefly describe test.
    c. Cite expected results.
    d. Provide space for checkoff by witness.

END OF SECTION

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INSTRUMENT LIST

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
LE/LIT-3123	L5	Level Element & Transmitter, Ultrasonic	Range: 0 to 10 feet	FT-I-005		FT-EP-152	
LE/LIT-3223	L5	Level Element & Transmitter, Ultrasonic	Range: 0 to 10 feet	FT-I-006		FT-EP-152	
LE/LIT-3323	L5	Level Element & Transmitter, Ultrasonic	Range: 0 to 10 feet	FT-I-007		FT-EP-152	
LE/LIT-3423	L5	Level Element & Transmitter, Ultrasonic	Range: 0 to 10 feet	FT-I-008		FT-EP-151	
LE/LIT-3523	L5	Level Element & Transmitter, Ultrasonic	Range: 0 to 10 feet	FT-I-009		FT-EP-151	
LE/LIT-3623	L5	Level Element & Transmitter, Ultrasonic	Range: 0 to 10 feet	FT-I-010		FT-EP-151	
LE/LIT-3723	L5	Level Element & Transmitter	Range: 0 to 10 feet	FT-I-011		FT-EP-151	
LE/LIT-3823	L5	Level Element & Transmitter,	Range: 0 to 10 feet	FT-I-012		FT-EP-151	
LE/LIT-1601	L5	Level Element & Transmitter	Range: 0 to 20 feet	FT-I-003		FT-EP-132	
LE/LIT-1602	L5	Level Element & Transmitter	Range: 0 to 20 feet	FT-I-003		FT-EP-132	
LE/LIT-3903	L5	Level Element & Transmitter	Range: 0 to 5 feet	FT-I-004		FT-EP-151	
LE/LIT-4410	L5	Level Element & Transmitter	Range: 0 to 5 feet	FT-I-016		FT-EP-401	
LE/LIT-6103	L5	Level Element & Transmitter	Range: 0 to 8 feet	FT-I-018		FT-EP-131	
LE/LIT-6203	L5	Level Element & Transmitter	Range: 0 to 8 feet	FT-I-018		FT-EP-131	
LSH-1710	L180	Leak Detector Sensor	+/- 1.0 mm	FT-I-002		FT-EP-403	
LSH-1720	L180	Leak Detector Sensor	+/- 1.0 mm	FT-I-002		FT-EP-403	

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
PI-1101	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-003		FT-EP-132	
PI-1201	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-003		FT-EP-132	
PI-1301	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-003		FT-EP-132	
PI-1401	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-003		FT-EP-132	
PI-1501	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-003		FT-EP-132	
PI-4103	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-013		FT-EP-132	
PI-4104	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-013		FT-EP-132	
PI-4203	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-014		FT-EP-132	
PI-4204	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-014		FT-EP-132	
PI-4303	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-015		FT-EP-132	
PI-4304	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-015		FT-EP-132	
PI-5105	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-017		FT-EP-141	
PI-6101	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-018		FT-EP-131	

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
PI-6201	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-018		FT-EP-131	
PI-2110	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-019		FT-EP-132	
PI-2210	P4	Pressure Gauge	Range: 0 to 100 psi; Options: Diaphragm Seal	FT-I-019		FT-EP-132	
PSH-1101	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-003		FT-EP-132	
PSH-1201	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-003		FT-EP-132	
PSH-1301	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-003		FT-EP-132	
PSH-1401	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-003		FT-EP-132	
PSH-1501	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-003		FT-EP-132	
PSH-5105	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-017		FT-EP-141	
PSH-2110	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-019		FT-EP-132	
PSH-2210	P7	Pressure Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-019		FT-EP-132	
PDIT-3121	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-005		FT-EP-132	
PDIT-3221	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-006		FT-EP-132	
PDIT-3321	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-007		FT-EP-132	

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
PDIT-3421	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-008		FT-EP-131	
PDIT-3521	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-009		FT-EP-131	
PDIT-3621	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-010		FT-EP-131	
PDIT-3721	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-011		FT-EP-131	
PDIT-3821	P3	Differential Pres Transmitter	Range: 0 to 10 feet	FT-I-012		FT-EP-131	
PDSH-5109	P7	Differential Pres Switch	Range: 0 to 100 psi; Options: Adj Dead Band	FT-I-017		FT-EP-141	
PIT-3124	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-005		FT-EP-132	
PIT-3224	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-006		FT-EP-132	
PIT-3324	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-007		FT-EP-132	
PIT-3424	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-008		FT-EP-131	
PIT-3524	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-009		FT-EP-131	
PIT-3624	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-010		FT-EP-131	
PIT-3724	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-011		FT-EP-131	
PIT-3824	P9	Pressure Transmitter	Range: 0 to 50 psi	FT-I-012		FT-EP-131	
FE/FIT-1103	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 12,000 gpm	FT-I-003		FT-EP-132	
FE/FIT-1503	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 12,000 gpm	FT-I-003		FT-EP-132	
FE/FIT-3122	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-I-005		FT-EP-132	
FE/FIT-3222	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-I-006		FT-EP-132	

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
FE/FIT-3322	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-1-007		FT-EP-132	
FE/FIT-3422	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-1-008		FT-EP-131	
FE/FIT-3522	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-1-009		FT-EP-131	
FE/FIT-3622	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-1-010		FT-EP-131	
FE/FIT-3722	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-1-011		FT-EP-131	
FE/FIT-3822	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 5 MGD	FT-1-012		FT-EP-131	
FE/FIT-4102	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 25 MGD	FT-1-013		FT-EP-132	
FE/FIT-4202	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 25 MGD	FT-1-014		FT-EP-132	
FE/FIT-4302	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 25 MGD	FT-1-015		FT-EP-132	
FE/FIT-4401	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 25 MGD	FT-1-016		FT-EP-401	
FE/FIT-4402	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 25 MGD	FT-1-016		FT-EP-401	
FE/FIT-6302	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 12,000 gpm	FT-1-018		FT-EP-141	
FE/FIT-2120	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 150 gpm	FT-1-019		FT-EP-132	

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
FE/FIT-2220	F52	Insertion Type Diff Pressure Flow Transmitter	Range: 0 to 150 gpm	FT-I-019		FT-EP-132	
FE/FIT-5107	F51	Thermal Mass Flow Meter	Range: 0 to 5,000 cfm	FT-I-017		MP-E-141	
FE/FIT-1504	F54	Insertion Type Mag Meter	Range: 0 to 3,000 gpm	FT-I-003		FT-E-102	
TSH-5104	T5	Temperature Switch	Range: 0 to 150 deg; Options: Adj Dead Band	FT-I-017		MP-E-141	
TI-5102	T9	Thermometer	Range: 0 to 150 deg	FT-I-017		FT-E-141	
TI-5103	T9	Thermometer	Range: 0 to 150 deg	FT-I-017		FT-E-141	
AE/AIT-3901	A16	Turbidity Analyzer	Range: 0 to 10 NTU	FT-I-004		FT-EP-131	
AE/AIT-3902	A33	TOC Analyzer	Range: 0 to 100%; 0 to 3 UVA	FT-I-004		MP-EP-131	
AE/AIT-3250	A10	Oxygen Sensor	Range: 0 to 25%; Adjustable Setpoint	FT-I-004		FT-EP-152	
AE/AIT-3550	A10	Oxygen Sensor	Range: 0 to 25%; Adjustable Setpoint	FT-I-004		FT-EP-151	
AE/AIT-3750	A10	Oxygen Sensor	Range: 0 to 25%; Adjustable Setpoint	FT-I-004		FT-EP-151	

PLC EQUIPMENT LIST

Name	Description	Qty.	Model	Manufacturer	Comments
LCP-AT	PROGRAMMABLE CONTROLLER		PLC	Allen-Bradley	
	ControlLogix Processor	1	1756-L62	Allen-Bradley	
	ControlLogix Processor Compact Flash Module	1	1784-CF64	Allen-Bradley	
	17 Slot I/O Chassis	2	1756-A17	Allen-Bradley	
	Power Supply	1	1756-PA75	Allen-Bradley	
	Ethernet 10-100M Bridge Module	1	1756-ENBT	Allen-Bradley	
	Empty Slot Filler for 1756 Chassis	8	1756-N2	Allen-Bradley	
	Control Net Bridge Module	2	1756-CNB	Allen-Bradley	
	Analog Input Module – 8 Point (36 Pin)	8	1756-IF8	Allen-Bradley	
	Digital Input Module – 16 Point, 24 VDC	7	1756-IB16	Allen-Bradley	
	Digital Output Module – 16 Point, 120 VAC	2	1756-OA16	Allen-Bradley	
	DeviceNet Module	8	1756-DNB	Allen-Bradley	
STANDARD SOFTWARE					
	RSNetWorx for ControlNet Software	1	9357-CNETL3	Allen-Bradley	
	RSNetWorx for DeviceNet Software	1	9357-DNETL3	Allen-Bradley	
	ControlLogix RSLogix 5000 Programming Software	1		Allen-Bradley	
Note 1: Where Allen-Bradley products are listed they are specified as no substitutions allowed.					

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PLC I/O LIST

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT		Panel LCP-AT				
LCP-AT	LAH-1710	South Filter Byp Vault Leak	FT-I-002	Critical	Alarm	AI
LCP-AT	LIR-1501	GAC Pump Wet Well Level	FT-I-003	Level		AI
LCP-AT	LIR-1601	GAC Pump Wet Well Level	FT-I-003	Level		AI
LCP-AT	FIR-1103	GAC Contactor BW Flow	FT-I-003	Flow		AI
LCP-AT	FIR-1503	Filter BW Flow	FT-I-003	Flow		AI
LCP-AT	FIR-1504	Back-up BW Water Supply	FT-I-003	Flow		AI
LCP-AT	LIR-3903	GAC Influent Channel Level	FT-I-004	Level		AI
LCP-AT	AIR-3901	GAC Effluent Turbidity	FT-I-004	Turbidity		AI
LCP-AT	AIR-3902	GAC Effluent TOC	FT-I-004	TOC		AI
LCP-AT	LIR-3123	GAC Contactor No. 1 Level	FT-I-005	Level		AI
LCP-AT	PIR-3121	GAC Contactor No. 1 Differential Pressure	FT-I-005	Diff Pres		AI
LCP-AT	PIR-3124	GAC Contactor No. 1 Effluent Pressure	FT-I-005	Pres		AI
LCP-AT	FIR-3122	GAC Contactor No. 1 Effluent Flow	FT-I-005	Flow		AI
LCP-AT	LIR-3223	GAC Contactor No. 2 Level	FT-I-006	Level		AI
LCP-AT	PIR-3221	GAC Contactor No. 2 Differential Pressure	FT-I-006	Diff Pres		AI
LCP-AT	PIR-3224	GAC Contactor No. 2 Effluent Pressure	FT-I-006	Pres		AI
LCP-AT	FIR-3222	GAC Contactor No. 2 Effluent Flow	FT-I-006	Flow		AI
LCP-AT	LIR-3323	GAC Contactor No. 3 Level	FT-I-007	Level		AI
LCP-AT	PIR-3321	GAC Contactor No. 3 Differential Pressure	FT-I-007	Diff Pres		AI
LCP-AT	PIR-3324	GAC Contactor No. 3 Effluent Pressure	FT-I-007	Pres		AI

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	FIR-3322	GAC Contactor No. 3 Effluent Flow	FT-I-007	Flow		AI
LCP-AT	LIR-3423	GAC Contactor No. 4 Level	FT-I-008	Level		AI
LCP-AT	PIR-3421	GAC Contactor No. 4 Differential Pressure	FT-I-008	Diff Pres		AI
LCP-AT	PIR-3424	GAC Contactor No. 4 Effluent Pressure	FT-I-008	Pres		AI
LCP-AT	FIR-3422	GAC Contactor No. 4 Effluent Flow	FT-I-008	Flow		AI
LCP-AT	LIR-3523	GAC Contactor No. 5 Level	FT-I-009	Level		AI
LCP-AT	PIR-3521	GAC Contactor No. 5 Differential Pressure	FT-I-009	Diff Pres		AI
LCP-AT	PIR-3524	GAC Contactor No. 5 Effluent Pressure	FT-I-009	Pres		AI
LCP-AT	FIR-3522	GAC Contactor No. 5 Effluent Flow	FT-I-009	Flow		AI
LCP-AT	LIR-3623	GAC Contactor No. 6 Level	FT-I-010	Level		AI
LCP-AT	PIR-3621	GAC Contactor No. 6 Differential Pressure	FT-I-010	Diff Pres		AI
LCP-AT	PIR-3624	GAC Contactor No. 6 Effluent Pressure	FT-I-010	Pres		AI
LCP-AT	FIR-3622	GAC Contactor No. 6 Effluent Flow	FT-I-010	Flow		AI
LCP-AT	LIR-3723	GAC Contactor No. 7 Level	FT-I-011	Level		AI
LCP-AT	PIR-3721	GAC Contactor No. 7 Differential Pressure	FT-I-011	Diff Pres		AI
LCP-AT	PIR-3724	GAC Contactor No. 7 Effluent Pressure	FT-I-011	Pres		AI
LCP-AT	FIR-3722	GAC Contactor No. 7 Effluent Flow	FT-I-011	Flow		AI
LCP-AT	LIR-3823	GAC Contactor No. 8 Level	FT-I-012	Level		AI
LCP-AT	PIR-3821	GAC Contactor No. 8 Differential Pressure	FT-I-011	Diff Pres		AI
LCP-AT	PIR-3824	GAC Contactor No. 8 Effluent Pressure	FT-I-012	Pres		AI
LCP-AT	FIR-3822	GAC Contactor No. 8 Effluent Flow	FT-I-012	Flow		AI
LCP-AT	FIR-4102	UV No. 1 Flow	FT-I-013	Flow		AI
LCP-AT	FIR-4202	UV No. 2 Flow	FT-I-014	Flow		AI

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	FIR-4302	UV No. 3 Flow	FT-I-015	Flow		AI
LCP-AT	LIR-4410	Splitter Box Level	FT-I-016	Level		AI
LCP-AT	FIR-5107	Air Supply Flow	FT-I-017	Flow		AI
LCP-AT	LIR-6103	EQ Basin Level	FT-I-018	Level		AI
LCP-AT	LIR-6203	EQ Basin Level	FT-I-018	Level		AI
LCP-AT	FIR-6302	Waste Sludge Flow	FT-I-018	Flow		AI
LCP-AT	FIR-2120	Slurry Water Pump No. 1 Flow	FT-I-019	Flow		AI
LCP-AT	FIR-2220	Slurry Water Pump No. 2 Flow	FT-I-019	Flow		AI
LCP-AT	MN-1751	FT-FWSP-001 Sample Pump	FT-O-002	Run	Status	DI
LCP-AT	AAL-3250	GAC Contactor Area Low Oxygen	FT-I-004	Critical	Alarm	DI
LCP-AT	AAL-3550	GAC Contactor Area Low Oxygen	FT-I-004	Critical	Alarm	DI
LCP-AT	AAL-3750	GAC Contactor Area Low Oxygen	FT-I-004	Critical	Alarm	DI
LCP-AT	MN-1752	FT-FWSP-002 Sample Pump	FT-I-016	Run	Status	DI
LCP-AT	MN-5101A	Air Scour Blower	FT-I-017	Run	Status	DI
LCP-AT	YI-5101	Air Scour Blower	FT-I-017	In Auto	Status	DI
LCP-AT	XA-5101A	Air Scour Blower	FT-I-017	Fail	Alarm	DI
LCP-AT	XA-5101B	Air Scour Blower	FT-I-017	Fault	Alarm	DI
LCP-AT	PAH-5109	Air Scour Blower	FT-I-017	High Pres Diff	Alarm	DI
LCP-AT	MN-5101B	Air Scour Blower	FT-I-017	Run	Status	DI
LCP-AT	XA-5101C	Air Scour Blower	FT-I-017	Common Fault	Alarm	DI
LCP-AT	MN-6100	EQ Pump No. 1	FT-I-018	Run	Status	DI
LCP-AT	YI-6100	EQ Pump No. 1	FT-I-018	In Auto	Status	DI
LCP-AT	XA-6100	EQ Pump No. 1	FT-I-018	Fault	Alarm	DI

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	TAH-6100	EQ Pump No. 1	FT-I-018	High Temp	Alarm	DI
LCP-AT	MAH-6100	EQ Pump No. 1	FT-I-018	Seal Leak	Alarm	DI
LCP-AT	MN-6200	EQ Pump No. 2	FT-I-018	Run	Status	DI
LCP-AT	YI-6200	EQ Pump No. 2	FT-I-018	In Auto	Status	DI
LCP-AT	XA-6200	EQ Pump No. 2	FT-I-018	Fault	Alarm	DI
LCP-AT	TAH-6200	EQ Pump No. 2	FT-I-018	High Temp	Alarm	DI
LCP-AT	MAH-6200	EQ Pump No. 2	FT-I-018	Seal Leak	Alarm	DI
LCP-AT	YI-1810	GAC PS Drain Pump	FT-I-018	In Remote	Status	DI
LCP-AT	MN-1810	GAC PS Drain Pump	FT-I-018	Run	Status	DI
LCP-AT	MAH-1810	GAC PS Drain Pump	FT-I-018	Seal Leak	Alarm	DI
LCP-AT	TAH-1810	GAC PS Drain Pump	FT-I-018	High Temp	Alarm	DI
LCP-AT	HS-2101A	Slurry Water Pump 1 Remote On/Off Cmd from LCP-2310	FT-I-019	On/Off	Control	DI
LCP-AT	HS-2101B	Slurry Water Pump 1 Remote On/Off Cmd from LCP-2320	FT-I-019	On/Off	Control	DI
LCP-AT	HS-2101C	Slurry Water Pump 1 Remote On/Off Cmd from LCP-2230	FT-I-019	On/Off	Control	DI
LCP-AT	HS-2101D	Slurry Water Pump 1 Remote On/Off Cmd from LCP-2340	FT-I-019	On/Off	Control	DI
LCP-AT	HS-2201A	Slurry Water Pump 2 Remote On/Off Cmd from LCP-2310	FT-I-019	On/Off	Control	DI
LCP-AT	HS-2201B	Slurry Water Pump 2 Remote On/Off Cmd from LCP-2320	FT-I-019	On/Off	Control	DI
LCP-AT	HS-2201C	Slurry Water Pump 2 Remote On/Off Cmd from LCP-2230	FT-I-019	On/Off	Control	DI

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	HS-2201D	Slurry Water Pump 2 Remote On/Off Cmd from LCP-2340	FT-I-019	On/Off	Control	DI
LCP-AT	ZI-2130A	Manual Valve FT-SWS-BFV-001	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2130B	Manual Valve FT-SWS-BFV-001	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2140A	Manual Valve FT-SWS-BFV-002	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2140B	Manual Valve FT-SWS-BFV-002	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-22130A	Manual Valve FT-SWS-BFV-003	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2230B	Manual Valve FT-SWS-BFV-003	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2240A	Manual Valve FT-SWS-BFV-004	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2240B	Manual Valve FT-SWS-BFV-004	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2401A	Manual Valve FT-SWS-BFV-005	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2401B	Manual Valve FT-SWS-BFV-005	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2402A	Manual Valve FT-SWS-BFV-006	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2402B	Manual Valve FT-SWS-BFV-006	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2403A	Manual Valve FT-SWS-BFV-013	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2403B	Manual Valve FT-SWS-BFV-013	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2404A	Manual Valve FT-SWS-BFV-014	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2404B	Manual Valve FT-SWS-BFV-014	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2405A	Manual Valve FT-SWS-BFV-015	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2405B	Manual Valve FT-SWS-BFV-015	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2406A	Manual Valve FT-SWS-BFV-016	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2406B	Manual Valve FT-SWS-BFV-016	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2407A	Manual Valve FT-SWS-BFV-017	FT-I-019	Fully Open	Position	DI

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	ZI-2407B	Manual Valve FT-SWS-BFV-017	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2408A	Manual Valve FT-SWS-BFV-018	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2408B	Manual Valve FT-SWS-BFV-018	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2409A	Manual Valve FT-SWS-BFV-019	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2409B	Manual Valve FT-SWS-BFV-019	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2410A	Manual Valve FT-SWS-BFV-020	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2410B	Manual Valve FT-SWS-BFV-020	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2411A	Manual Valve FT-SWS-BFV-021	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2411B	Manual Valve FT-SWS-BFV-021	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2412A	Manual Valve FT-SWS-BFV-022	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2412B	Manual Valve FT-SWS-BFV-022	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2413A	Manual Valve FT-SWS-BFV-023	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2413B	Manual Valve FT-SWS-BFV-023	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2414A	Manual Valve FT-SWS-BFV-024	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2414B	Manual Valve FT-SWS-BFV-024	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2415A	Manual Valve FT-SWS-BFV-025	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2415B	Manual Valve FT-SWS-BFV-025	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2416A	Manual Valve FT-SWS-BFV-026	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2416B	Manual Valve FT-SWS-BFV-026	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2417A	Manual Valve FT-SWS-BFV-027	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2417B	Manual Valve FT-SWS-BFV-027	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2418A	Manual Valve FT-SWS-BFV-028	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2418B	Manual Valve FT-SWS-BFV-028	FT-I-019	Fully Closed	Position	DI

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	ZI-2419A	Manual Valve FT-SWS-BFV-007	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2419B	Manual Valve FT-SWS-BFV-007	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2420A	Manual Valve FT-SWS-BFV-008	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2420B	Manual Valve FT-SWS-BFV-008	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2421A	Manual Valve FT-SWS-BFV-009	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2421B	Manual Valve FT-SWS-BFV-009	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2422A	Manual Valve FT-SWS-BFV-010	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2422B	Manual Valve FT-SWS-BFV-010	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2423A	Manual Valve FT-SWS-BFV-011	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2423B	Manual Valve FT-SWS-BFV-011	FT-I-019	Fully Closed	Position	DI
LCP-AT	ZI-2424A	Manual Valve FT-SWS-BFV-012	FT-I-019	Fully Open	Position	DI
LCP-AT	ZI-2424B	Manual Valve FT-SWS-BFV-012	FT-I-019	Fully Closed	Position	DI
LCP-AT	HS-1751	FT-FWSP-001 Sample Pump	FT-I-002	Start/Stop	Control	DO
LCP-AT	TC-7800	Exterior Pole Light Control	FT-I-002	On/Off	Control	DO
LCP-AT	HS-1752	FT-FWSP-002 Sample Pump	FT-I-016	Start/Stop	Control	DO
LCP-AT	HC-1810	GAC PS Drain Pump	FT-I-016	Start/Stop	Control	DO
LCP-AT	HC-5101	Air Scour Blower	FT-I-017	Start/Stop	Control	DO
LCP-AT	HC-6100	EQ Pump No. 1	FT-I-018	Start/Stop	Control	DO
LCP-AT	HC-6200	EQ Pump No. 2	FT-I-018	Start/Stop	Control	DO
LCP-AT	MN-2101A	Slurry Water Pump 1 Status at LCP-2310	FT-I-019	Run	Status	DO
LCP-AT	MN-2101B	Slurry Water Pump 1 Status at LCP-2320	FT-I-019	Run	Status	DO
LCP-AT	MN-2101C	Slurry Water Pump 1 Status at LCP-2330	FT-I-019	Run	Status	DO
LCP-AT	MN-2101D	Slurry Water Pump 1 Status at LCP-2340	FT-I-019	Run	Status	DO

PLC	Point No	Description	P&ID	Function	Type	I/O
LCP-AT	MN-2201A	Slurry Water Pump 2 Status at LCP-2310	FT-I-019	Run	Status	DO
LCP-AT	MN-2201B	Slurry Water Pump 2 Status at LCP-2320	FT-I-019	Run	Status	DO
LCP-AT	MN-2201C	Slurry Water Pump 2 Status at LCP-2330	FT-I-019	Run	Status	DO
LCP-AT	MN-2201D	Slurry Water Pump 2 Status at LCP-2340	FT-I-019	Run	Status	DO
		Existing Filter Bldge Panel				
CP-3 (EX)	FIR-4401	Clearwell No. 1 Flow	FT-I-016	Flow		AI
CP-3 (EX)	FIR-4402	Clearwell No. 2 Flow	FT-I-016	Flow		AI
CP-4 (EX)	LAH-4107	Chemical Feed Vault Flood Alarm	FT-I-016	Critical	Alarm	AI
CP-4 (EX)	JA-7100	Power Failure	FT-I-016	Critical	Alarm	DI
CP-4 (EX)	MN-7100	Generator Run	FT-I-016	Run	Status	DI
CP-4 (EX)	XA-7100	Generator Fail	FT-I-016	Critical	Status	DI
CP-4 (EX)	LAL-7100	Low Generator Fuel	FT-I-016	Level	Alarm	DI
CP-4 (EX)	ZI-7101	Auto Transfer Switch Normal Position	FT-I-016	Position	Status	DI
CP-4 (EX)	ZI-7102	Auto Transfer Switch Emergency Position	FT-I-016	Position	Status	DI

CONTROL PANEL SCHEDULE

Panel No.	Service	Mounting	NEMA	Dimensions H	W	D	FDT	Space Heater	Serv. Lights, Outlets	Environment	SS
LCP-AT	AT Building PLC Panel	Freestanding	1	72	60	36	Yes		Yes	Inside	
LCP-CONT	AT Building Contactor Area	Freestanding	12	63	24	33	Yes			Inside	
LCP-2310	Slurry Water Pump CP	Wall	4X	12	10	6		Yes		Outside	SS
LCP-2320	Slurry Water Pump CP	Wall	4X	12	10	6		Yes		Outside	SS
LCP-2330	Slurry Water Pump CP	Wall	4X	12	10	6		Yes		Outside	SS
LCP-2340	Slurry Water Pump/Valve CP	Wall	4X	12	10	6				Inside, Corrosive	SS

Column Descriptions:

FDT: Factory Demonstration test required.
Dimensions: Maximum space available for panel.
SS: Stainless Steel.

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CH2M HILL LOOP STATUS REPORT—EXAMPLE FORMAT Rev.06.05.92

Project Name: *Newport News WTP*	Project No. *WDC23456.C1*
FUNCTIONAL REQUIREMENTS:	
1. Measure, locally indicate, and transmit RAS flow to LP-10.	
2. At LP-10 indicate flow and provide flow control by modulation of FCV-10-2.	
3. Provide high RAS flow alarm on LP-10.	

COMPONENT STATUS (Check and initial each item when complete)

Tag Number	Delivered	Tag ID Checked	Installation	Termination Wiring	Termination Tubing	Calibration	
FE/FIT-10-2	*Jan-12-90 DWM*	*Jan-12-90 DWM*	*Feb-7-90 DWM*	*Mar-5-90 DWM*	*N.A.*	*May-6-90 VDA*	
FIC-10-2	*Jan-12-90 DWM*	*Jan-12-90 DWM*	*Mar-5-90 DWM*	*Apr-4-90 DWM*		*May-4-90 VDA*	
FSH-10-2	*Jan-12-90 DWM*	*Jan-12-90 DWM*	*Mar-5-90 DWM*	*Apr-4-90 DWM*		*May-7-90 VDA*	
FAH-10-2	*Jan-12-90 DWM*	*Jan-12-90 DWM*	*Mar-5-90 DWM*	*Apr-4-90 DWM*		*May-7-90 VDA*	
FCV-10-2	*Mar-2-90 DWM*	*Mar-2-90 DWM*	*Apr-20-90 DWM*	*Apr-30-90 DWM*		*May-16-90 VDA*	

REMARKS: None.

Loop Ready for Operation	By: *D.W. Munzer*	Date: *May-18-90*	Loop No.: *10-2*

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CH2M HILL INSTRUMENT CALIBRATION SHEET—EXAMPLE—ANALYZER/TRANSMITTER Rev.06.05.92

COMPONENT	MANUFACTURER		PROJECT
Code: *A7*	Name: *Leeds & Northrup*		Number: *WDC30715.B2*
Name: *pH Element & Analyzer/Transmitter*	Model: *12429-3-2-1-7*	Serial #: *11553322*	Name: *UOSA AWT PHASE 3*

FUNCTIONS

	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N	CONTROL? N
Indicate? Y Record? N	Chart:			Describe:	Action? direct / reverse Modes? P / I / D
	Scale:	*1-14*	*pH units*		SWITCH? N Unit Range:
Transmit/ Convert? Y	Input:	*1-14*	*pH units*		Differential: fixed/adjustable
	Output:	*4-20*	*mA dc*		Reset? automatic / manual

ANALOG CALIBRATIONS						
REQUIRED			AS CALIBRATED			
Input	Indicated	Output	Increasing Input		Decreasing Input	
			Indicated	Output	Indicated	Output
1.0	*1.0*	*4.0*	*1.0*	*4.0*	*1.0*	*3.9*
2.3	*2.3*	*5.6*	*2.2*	*5.5*	*2.3*	*5.6*
7.5	*7.5*	*12.0*	*7.5*	*11.9*	*7.5*	*12.0*
12.7	*12.7*	*18.4*	*12.7*	*18.3*	*12.6*	*18.3*
14.0	*14.0*	*20.0*	*14.0*	*20.0*	*14.0*	*20.0*
CONTROL MODE SETTINGS:			P: *N.A.*	I:	D:	

DISCRETE CALIBRATIONS					Note No.
REQUIRED			AS CALIBRATED		
Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
	(note rising or falling)		(note rising or falling)		
1.	*N.A.*		*N.A.*		
2.					*1.*
3.					
4.					
5.					
6.					

#	NOTES:	Component Calibrated and Ready for Start-up
	1. Need to recheck low pH calibration solutions.	By: *J.D. Sewell*
		Date: *Jun-6-92*
		Tag No.: *AIT-12-6*[pH]

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CH2M HILL **I&C VALVE ADJUSTMENT SHEET—EXAMPLE** Rev.06.05.92

PARTS	Project Name: *SFO SEWPCP*	Project Number: *SFO10145.G2*
Body	Type: *Vee-Ball*	Mfr: *Fisher Controls*
	Size: *4-inch*	Model: *1049763-2*
	Line Connection: *159 # ANSI Flanges*	Serial #: *1003220*
Operator	Type: *Pneumatic Diaphragm*	Mfr: *Fisher Controls*
	Action: *Linear – Modulated*	Model: *4060D*
	Travel: *3-inch*	Serial #: *2007330*
Positioner	Input Signal: *3-15 psi*	Mfr: *Fisher Controls*
	Action: *Direct - air to open*	Model: *20472T*
	Cam: *Equal percentage*	Serial #: *102010*
Pilot	Action:	Mfr:
Solenoid	Rating: *None*	Model: Serial #:
I/P	Input: *4-20 mA dc*	Mfr: *Taylor*
Converter	Output: *3-15 psi*	Model: *10-T-576-3*
	Action: *Direct*	Serial #: *1057-330*
Position	Settings: *Closed / Open 5 deg, rising*	Mfr: *National Switch*
Switch	Contacts: *Close / Close*	Model: *1049-67-3*
		Serial #: *156 &157*
Power	Type: *Pneumatic*	Air Set Mfr: *Air Products*
Supply	Potential: *40 psi*	Model: *3210D*
		Serial #: *1107063*

ADJUSTMENTS	Initial	Date	**VERIFICATION**	Initial	Date
Air Set	*JDS*	*Jun-06-92*	Valve Action	*JDS*	*Jun-03-92*
Positioner	*JDS*	*Jun-06-92*	Installation	*JDS*	*Jun-03-92*
Position Switches	*JDS*	*Jun-06-92*	Wire Connection	*JDS*	*Jun-04-92*
I/P Converter	*JDS*	*Jun-07-92*	Tube Connection	*JDS*	*Jun-04-92*
Actual Speed	*JDS*	*Jun-07-92*			

REMARKS: *Valve was initially installed backwards.*	**Valve Ready for Start-up**
Observed to be correctly installed May-25-92	By: *J.D. Sewell*
	Date: *Jun-07-92*
	Tag No.: *FCV-10-2-1*

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CH2M HILL PERFORMANCE TEST SHEET - EXAMPLE Rev.06.05.92

Project Name: *SFO SEWPCP Plant Expansion*	Project No.: *SFO12345.C1*

Demonstration test(s): For each functional Requirement of the loop:
(a) List and number the requirement. (b) Briefly describe the demonstration test.
(c) Cite the results that will verify the required performance. (d) Provide space for signoff.

1. MEASURE EFFLUENT FLOW

1.a With no flow, water level over weir should be zero and

FIT indicator should read zero. *Jun-20-92 BDG*

2. FLOW INDICATION AND TRANSMISSION TO LP & CCS

With flow, water level and FIT indicator should be related by expression

*Q(MGD) = 429*H**(2/3) (H = height in inches of water over weir).*

Vary H and observe that following.

2.a Reading of FIT indicator. *Jun-6-92 BDG*

2.b Reading is transmitted to FI on LP-521-1 *Jun-6-92 BDG*

2.c Reading is transmitted and displayed to CCS. *Jun-6-92 BDG*

H(measured)	*0*	*5*	*10*	*15*
Q(computed)	*0*	*47.96*	*135.7*	*251.7*
Q(FIT indicator)	*0*	*48.1*	*137*	*253*
Q(LI on LP-521-1)	*0*	*48.2*	*138*	*254*
Q(display by CCS)	*0*	*48.1*	*136.2*	*252.4*

Forms/Sheets Verified	By	Date	**Loop Accepted By Owner**
Loop Status Report	*J.D. Sewell*	*May-18-92*	By: *J.D. Smith*
Instrument Calibration Sheet	*J.D. Sewell*	*May-18-92*	Date: *Jun-6-92*
I&C Valve Calibration Sheet	*N.A.*		
Performance Test	By	Date	
Performed	*J. Blow MPSDC Co.*	*Jun-6-92*	
Witnessed	*B. DeGlanville*	*Jun-6-92*	Loop No.: *30-12*

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SECTION 40 91 00
INSTRUMENTATION AND CONTROL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. This section gives general requirements for instrumentation and control components.

PART 2 PRODUCTS

2.01 GENERAL

A. Article Mechanical Systems Components covers requirements of mechanical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

B. Article Electrical Components covers requirements for electrical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

C. All other Part 2 articles cover components that are referenced by Instrument Lists or Data Sheets in Section 40 90 00, Instrumentation and Control for Process Systems, or by specific component numbers in other PIC subsections.

2.02 MECHANICAL SYSTEMS COMPONENTS

A. Pressure Gauge: For other than process variable measurement.

1. Dial Size: Nominal 2-inch dial size.
2. Accuracy: 2 percent of span.
3. Scale Range: Such that normal operating pressure lies between 50 percent and 80 percent of scale range.
4. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
5. Manufacturers and Products:
    a. Ashcroft Utility; Gauge Series 1000.
    b. Marsh; Standard Gauge Series.
    c. Ametek U.S.; Gauge Series P500.
    d. Acculite; Series 2000.

B. Solenoid Valve, Two-Way:

1. Type: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
2. Materials:
    a. Body: Brassed or stainless steel globe valves as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
    b. Valve Seat: Buna-N.
3. Size: Normally closed or opened, as noted.
4. Coil: 115V ac, unless noted otherwise.
5. Solenoid Enclosure: NEMA 4.
6. Manufacturer and Product: ASCO; Red Hat Series 8260.

C. Copper Tubing and Fittings:

1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on Drawings.
3. Manufacturers:
    a. Parker-Hannifin.
    b. Swagelok tube fittings.

D. Plastic Tubing and Fittings:

1. Tubing:
    a. Polyethylene capable of withstanding 190 psig at 175 degrees F.
    b. Manufacturers and Products:
        1) Dekoron; Type P.
        2) Imperial Eastman; Poly-Flo black instrument tubing.
2. Fittings:
    a. Type: Brass compression.
    b. Manufacturers and Products:
        1) Imperial Eastman; Poly-Flo tube fittings.
        2) Dekoron; E-Z fittings.

E. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on Drawings.

F. Stainless Steel Fittings:

1. Compression Type:
    a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, flareless.
    b. Manufacturers and Products:
        1) Parker Flodar; BA Series.
        2) Swagelok tube fittings.
        3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.
2. Socket Weld Type:
    a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, 3,000 psi maximum working pressure, safety factor 4:1.
    b. Manufacturers:
        1) Cajon.
        2) Swagelok.
        3) Parker WELDLOK.

2.03 ELECTRICAL COMPONENTS

A. Terminal Blocks for Enclosures:

1. General:
    a. Connection Type: Screw compression clamp.
    b. Compression Clamp:
        1) Complies with DIN-VDE 0611.
        2) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
        3) Guides strands of wire into terminal.
    c. Screws: Hardened steel, captive, and self-locking.
    d. Current Bar: Copper or treated brass.
    e. Insulation:
        1) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
        2) Two funneled shaped inputs to facilitate wire entry.
    f. Mounting:
        1) Standard DIN rail.
        2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
        3) End Stops: Minimum of one at each end of rail.
    g. Wire Preparation: Stripping only permitted.
    h. Jumpers: Allow jumper installation without loss of space on terminal or rail.

i. Marking System:
   1) Terminal number shown on both sides of terminal block.
   2) Allow use of preprinted and field marked tags.
   3) Terminal strip numbers shown on end stops.
   4) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
   5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

j. Test Plugs: Soldered connections for 18 AWG wire.
   1) Pin Diameter: 0.079 inch.
   2) Quantity: 10.
   3) Manufacturer and Product: Entrelec; Type FC2.

2. Terminal Block, General Purpose:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 24 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Spacing: 0.25 inch, maximum.
   g. Test Sockets: One screw test socket 0.079-inch diameter.
   h. Manufacturer and Product: Entrelec; Type M4/6.T.
3. Terminal Block, Ground:
   a. Wire Size: 24 AWG to 10 AWG.
   b. Rated Wire Size: 10 AWG.
   c. Color: Green and yellow body.
   d. Spacing: 0.25 inch, maximum.
   e. Grounding: Electrically grounded to mounting rail.
   f. Manufacturer and Product: Entrelec; Type M4/6.P.
4. Terminal Block, Blade Disconnect Switch:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 10 amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body, orange switch.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturer and Product: Entrelec; Type M4/6.SNT.
5. Terminal Block Diode:
   a. Rated Voltage: 24V dc.
   b. Rated Current: 30 ma.
   c. Wire Size: 16 AWG.
   d. Manufacturer and Product: Phoenix Contact ST-IN.
6. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 25 amp.

c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Fuse: 0.25 inch by 1.25 inches.
g. Indication: LED diode 24V dc.
h. Spacing: 0.512 inch, maximum.
i. Manufacturer and Product: Entrelec; Type ML10/13.SFD.

7. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 25 amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Fuse: 0.25 inch by 1.25 inches.
   g. Indication: Neon lamp, 110V ac.
   h. Leakage Current: 1.8 mA, maximum.
   i. Spacing: 0.512 inch, maximum.
   j. Manufacturer and Product: Entrelec; Type ML10/13.SFL.
8. Terminal Block, Fused, 120V ac, High Current:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 35 amps.
   c. Wire Size: 18 AWG to 8 AWG.
   d. Rated Wire Size: 8 AWG.
   e. Color: Gray.
   f. Fuse: 13/32 inch by 1.5 inches.
   g. Spacing: 0.95 inch, maximum.
9. Manufacturer and Product: Entrelec; Type MB10/24.SF.

B. Relays:

1. General:
   a. Relay Mounting: Plug-in type socket.
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: Rail.
   e. Provide holddown clips.
2. Signal Switching Relay:
   a. Type: Dry circuit.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 5 amps at 28V dc or 120V ac.
   d. Contact Material: Gold or silver.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 0.9 watt (dc), 1.2VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.

h. Expected Electrical Life at Rated Load: 100,000 operations.
i. Indication Type: Neon or LED indicator lamp.
j. Seal Type: Hermetically sealed case.
k. Manufacturer and Product: Potter and Brumfield; Series KH/KHA.

3. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: Potter and Brumfield; Series KUP.
4. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
   i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 30V dc or 277V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Operating Temperature: Minus 10 degrees C to 55 degrees C.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
   i. Time Delay Setpoint: As noted or shown.
   j. Mode of Operation: As noted or shown.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   l. Manufacturer and Products: Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.

C. Surge Suppressors:

1. General:
    a. Construction: First-stage high-energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
    b. Response: 5 nanoseconds maximum.
    c. Recovery: Automatic.
    d. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
2. Suppressors on 120V ac Power Supply Connections:
    a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
    b. First-Stage Clamping Voltage: 350 volts or less.
    c. Second-Stage Clamping Voltage: 210 volts or less.
    d. Continuous Operation: Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum at 130V ac.
3. Suppressors on Analog Signal Lines:
    a. Test Waveform: Linear 8 microsecond rise in current form 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
    b. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
        1) dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
        2) dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
        3) Maximum Loop Resistance: 18 ohms per conductor.
4. Physical Characteristics:
    a. Mounted in Enclosures: Encapsulated inflame retardant epoxy.
    b. For Analog Signals Lines: EDCO PC-642 or SRA-64 series.
    c. For 120V ac Lines: EDCO HSP-121.
    d. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples. EDCO SS64 series.
    e. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
        1) Enclosure:
            a) NEMA 4X fiberglass or Type 316 stainless steel with door.
            b) Maximum Size: 12 inches by 12 inches by 8 inches deep.
        2) Manufacturer and Product: EDCO; SLAC series.

D. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.

2.04 I&C COMPONENTS

A. A10 Oxygen Sensor and Transmitter:

1. General:
   a. Function: Continuously monitor ambient air for low oxygen levels.
   b. Sensor: Bottom mounted on the transmitter.
   c. Parts: Element, transmitter, controller, calibrator and ancillaries.
2. Performance:
   a. Range: 0 to 25 percent oxygen.
   b. Repeatability: Plus or minus 1 percent of full scale.
   c. Long Term Drift: Less than 5% per year.
   d. Response Time: Less than 12 seconds.
   e. Temperature, Operating:
      1) Element/Transmitter: Minus 4 degrees F to plus 122 degrees F.
3. Element/Sensor:
   a. Number of Sensors: One.
   b. Mounting: Side mount on transmitter..
4. Transmitter:
   a. LCD Display.
   b. Nonintrusive interface for functional, calibration, and alarm testing.
   c. Enclosure:
      1) NEMA 4X, Type 316 stainless steel.
   d. Audible alarm.

5. Power:
   a. Transmitter: 18 to 30V dc.
   b. Controller: 85 to 264V ac, 50/60 Hz.
6. Signal Interfaces:
   a. Transmitter:
      1) Three SPDT relays rated for 230V ac at 5 amps resistive.
         a) Configured for warning and alarm levels, and unit fault.
      2) Analog Output: 4 mA to 20 mA dc analog output capable of driving 600 ohms at 24V dc.
7. Ancillaries:
   a. Red alarm strobe.
   b. Piezo Buzzer.
8. Manufacturers and Products:
   a. MSA; Toxgard II or equal.

B. A16 Turbidity Element and Transmitter:

1. General:
   a. Function: Continuously measure, indicate, and transmit a signal proportional to turbidity of a sample stream of process fluid.
   b. Type: Light scatter detection measurement using a 90-degree scatter photocell detector.
   c. Parts: Element, transmitter (controller), interconnecting cable, mounting hardware, and expendables.
2. Performance:
   a. Complies with US EPA Method 180.1.
   b. Range: 0 NTU to 100 NTU.
   c. Displayed Resolution:
      1) 0.0001 NTU up to 10 NTU.
      2) 0.001 NTU for 10 NTU and greater.
   d. Repeatability: Plus or minus 1 percent or plus or minus 0.002 NTU, whichever is greater.
   e. Initial Response Time: Within 75 seconds for a full-scale step change.
   f. Required Flow: 200 ml to 750 ml per minute.
   g. Sample Temperature: minus 20 C to 60 degrees C.
   h. Operating Temperature:
      1) Single Sensor System: 0 degrees C to 50 degrees C.
      2) Dual Sensor System: 0 degrees to 40 degrees C.
   i. Operating Humidity: 5 percent to 95 percent, noncondensing.
   j. Accuracy:
      1) From 0 NTU to 40 NTU: Plus or minus 2 percent of reading or plus or minus 0.015 NTU, whichever is greater.

2) From 40 NTU to 100 NTU: Plus or minus 5 percent of reading.

3. Element:
   a. General: Flow-through body using focused light and submerged photocell to measure 90-degree scattered light within the fluid.
   b. Submerged photocell that does not require glass windows and flow cells.
   c. Internal bubble trap and vent.
   d. Polystyrene body.
   e. Optical components mounted in a sealed head assembly that is removable without disturbing sample flow.
   f. Dimensions: 10 inches by 13 inches by 16 inches, nominal.
   g. Fittings:
      1) Sample Inlet: 1/4-inch NPT female, 1/4-inch compression fitting.
      2) Drain: 1/2-inch NPT female, 1/2-inch hose bib.
4. Transmitter:
   a. Features:
      1) Signal Average Time: User selectable from 6, 30, 60, 90 seconds with a 60-second default.
      2) Four-digit LCD display.
      2) Mounting: Wall and floor stand.
      3) Accepts either one or two elements.
      4) Data logging for 15 minutes, 1 hour, 24 hours, 30 days or 180 days.
   b. Enclosure:
      1) NEMA 4X (indoor).
      2) Dimensions, Nominal: 6 inches by 6 inches by 6 inches.
      3) Mounting: Wall, pole, panel, and floor stand.
   c. Signal Interface:
      1) Analog Output:
         a) Two 4 mA to 20 mA dc suitable for load impedance of up to 500 ohms.
         b) Span configurable over any portion of the 0 to 100 NTU range.
         c) Output Span: As noted.
      2) Alarm Contacts: Three independent alarm setpoints, each SPDT and rated 5A continuous at 230V ac, minimum. Each setpoint adjustable over full range.
      3) Digital Communications:
         a) MODBUS/RS485, MODBUS/RS232, LonWorks protocols: If noted.

4) Wireless Communications: IR port supports MODBUS communication with a computer or directly into a Personal Digital Assistant (PDA).

5. Power Supply: Input: 100V ac to 230V ac, 50-Hz to 60-Hz, auto-selecting, 40 VA.
6. Cabling: As required.
7. Accessories and Expendables:
   a. Calibration Kits:
      1) Stablcal Verification Standards:
         a) 1 liter of 20 NTU calibration standard.
         b) 1 liter of 1 NTU verification standard.
         c) Quantity: One each for each turbidimeter.
         d) Two Stablcal calibration cylinders, minimum.
      2) Formazin Calibration Standard:
         a) Kit including 0.5 liter of 4000 NTU Formazin, pipet, and calibration cylinder.
         b) Quantity: One for each turbidimeter.
      3) Order expendables just before startup.
   b. Verification Module: 1 NTU, unless otherwise noted.
8. Manufacturer and Product: Hach Company; Model 1720E low range turbidimeter with SC100 controller.

C. A33 TOC Element and Transmitter:

1. General:
   a. Function: Measure, indicate, and transmit TOC of the GAC Contactor effluent.
   b. Type: 254nm wavelength UV light source
   c. Parts: Element, transmitter, and cable.
2. Service:
   a. Fluid: GAC Contactor effluent water.
   b. Operating Temperature Range: 32 degrees F to 113 degrees F.
3. Performance:
   a. Range: 0-100 UVT, 0-3 UVA.
   b. Sampling Time: 4 seconds.
   c. Accuracy: 1.0. percent of UVT.
   d. Resolution: .0.1 percent UVT.
4. Element (Sensor):
   a. Features:
      1) Light Source: Low pressure mercury UV lamp.
5. Transmitter (Monitor/Controller):
   a. Features:
      1) User Interface:
         a) Backlit liquid crystal display.

b) Menu driven functions.
c) Keypad interface.
2) Enclosure:
a) Type: NEMA 4X, polycarbonate.
b) Mounting: Wall.
b. Enclosure:
1) NEMA 4X, fiberglass.
2) Nominal Size: 9W by 11H by 6D inches.
3) Mounting: Wall.
6. Power:
a. Transmitter: 120VAC.
7. Signal Interface (Transmitter):
a. Analog Output: 4 mA to 20 mA dc for load impedance 0 ohm to 300 ohms minimum for 24V dc supply without load adjustment.
b. Discrete Output(s):
1) Two solid state relay outputs, contacts rated for 24V dc.
2) Descriptions: Diagnostic alarm, high/low alarms.
c. Chemtrac Systems, Inc.; UV Organics Monitor UVM5000 or equal.

D. F51 Flow Element and Transmitter, Thermal Mass Flow:

1. General:
a. Function: Directly measure, indicate, and transmit mass flow of gas in pipe.
b. Type: Insertion type, thermal dispersion detection probe using platinum resistance temperature detectors (RTD).
c. Parts: Elements, transmitter, and interconnecting cable.
2. Performance:
a. Process Gas: As noted or shown.
b. Range for Air at 70 Degrees F and 14.7 psia:
1) As noted, within the following:
a) 0.25 to 1,600 standard fps.
b) 0.25 to 200 actual fps.
c. Calibrated Span: As noted.
d. Accuracy:
1) Flow: Plus or minus 1 percent of reading plus 0.5 percent full scale.
2) Temperature: Plus or minus 2 degrees F.
e. Repeatability:
1) Flow: Plus or minus 0.5 percent of reading.
2) Temperature: Plus or minus 1 degree F.

f. Temperature, Operating:
    1) Flow Element: Minus 50 degrees F to plus 350 degrees F, unless otherwise noted.
    2) Transmitter Housing: 0 degree F to plus 150 degrees F.
g. Pressure, Operating, Flow Element: Up to 50 psig, unless otherwise noted.

3. Flow Element:
    a. Features:
        1) Insertion Length: As noted or manufacturer's recommendation.
        2) Wetted Surfaces Materials: Type 316 stainless steel with nickel braze, unless otherwise noted.
    b. Process Connection:
        1) Line Size: As noted or shown.
        2) Connection Type: Retractable sensor with graphite-packed gland with 1-1/4-inch MNPT, unless otherwise noted.
        3) Connection Material: Type 316 stainless steel, unless otherwise noted.
    c. Sensor Enclosure:
        1) Type: Aluminum, NEMA 4X, rated for Classes 1 and 2, Divisions 1 and 2, Groups B, C, D, E, F, G, and Eexd IIC; unless otherwise noted.
4. Transmitter:
    a. Features: 4-line by 20-character LCD, keypad programmable.
    b. Nonvolatile memory.
    c. Signal Interface:
        1) Outputs:
            a) Analog: Two isolated 4 mA to 20 mA dc for maximum 600 ohm load, unless otherwise noted.
            b) Discrete:
                (1) Two independently adjustable 10 amps at 115V ac or 24V dc.
                (2) Configurable as high or low flow or process temperature.
        2) Communication:
            a) RS-232C serial port enables remote adjustment and reading of process values and set points.
            b) Protocols: If and as noted.
    d. Power:
        1) Selectable: 115V ac, 230V ac, 24V dc.
    e. Electrical Connection: 1-inch FNPT.
    f. Transmitter Enclosure:
        1) Type: Fiberglass NEMA 4X, unless otherwise noted.
        2) Mounting: Remote from sensor.

g. Single factory calibration, unless otherwise noted.

5. Cables:
   a. Length: As required.
   b. Cable Jacket: PVC rated for 220 degrees F, unless otherwise noted.
6. Manufacturer and Product: Fluid Components International; Model GF90.

E. F52 Flow Element and Transmitter, Insertion Type Differential Pressure

1. General:
   a. Function: Averaging Pitot Tubes (Annubars) are insertion type primary elements for measuring flow of liquids. The Annubars produced a differential pressure for measurement by a differential pressure transmitter.
   b. Type: Pitot Tube or Annubar insertion probes.
   c. Parts: Sensor, cable, pressure transmitter.
2. Service:
   a. Operating Temperature:
      1) Sensor: 32 to 110 degrees F, unless otherwise noted (32 to 175 degrees F an available option).
      2) Transmitter: minus 14 to 140 degrees F.
   b. Sensor Operating Pressure: up to 250 psig.
3. Performance:
   a. Flow Range: As noted.
   b. Accuracy:
      1) Plus or minus 1 percent of reading from 0 to 20 fps.
   c. Velocity Range:
      1) Up to 20 fps for process pipes less than 24 inches.
      2) Up to 10 fps for process pipes from 24 through 42 inches.
      3) Up to 7.5 fps for process pipes from 43 through 60 inches.
4. Process Pipe Size: As noted.
5. Sensor:
   a. 316 Stainless Steel.
   b. Cable: Polyurethane outer jacket.
   c. Wetted Parts: Type 316 stainless steel.
   d. Compression Seal: Silicone rubber.
6. Transmitter:
   a. Enclosure Rating: NEMA 4X/IP65.
   b. Enclosure Materials: Glass filled polypropylene with clear polycarbonate window.
   c. Configuration:
      1) Keypad programming.
      2) Two levels of password protection.

d. Signal Interfaces:
   1) 4 mA to 20 mA dc capable of driving load impedances up to 800 ohms.
      a) Galvanically isolated.
      b) Fully programmable for zero and full scale.
   2) Alarms:
      a) Two separate isolated protected transistor switches.
      b) Capable of sinking less than 250 mA at less than 35 volts.
      c) Configurable for high/low flow rates, empty pipe, fault conditions, forward/revise, analog over range.
   3) Pulse Frequency Output:
      a) For flow rate or for external totalizer.
      b) Capable of sinking less than 250 mA at less than 35 volts.

e. Keypad and Display:
   1) 3-line, 16 character backlit LCD display with 1/2-inch numerals for flow rate and two lines for engineering units, totalizers, alarm status, and percent of range.
   2) 9-digit totalizer.

7. Power Supply:
   a. 120V ac, unless otherwise noted.
   b. Universal switch for 85 to 265 Volts, 45 to 400 Hz at 20 VA.
8. Accessories:
   a. 19-tube bundle flow strengthener to reduce upstream piping requirements.
9. Manufacturers and Products:
   a. Rosemount Model 3051SFA Annubar Flowmeter complete with Rosemount 3051S pressure transmitter and Rosemount 485 Annubar Primary Element.
   b. Veris Verabar, Annubar or Accelabar with Endress Hauser Pressure Transmitter.
   c. Or approved equal.

F. F54 Flow Element and Transmitter, Insertion Type Magmeter:

1. General:
   a. Function: An array of electromagnetic electrodes are strategically located on the insertable sensor that spans the entire pipe diameter.
   b. Type: Electromagnetic insertion type.
   c. Parts: Sensor, cable, transmitter.
2. Service:
   a. Sensor Operating Temperature: -4 degrees to 140 degrees F.

b. Sensor Operating Pressure: Up to 250 psig.

3. Performance:
   a. Flow Range: As noted.
   b. Accuracy: Plus or minus 1 percent of reading from 0 to 20 fps.
4. Process Pipe Size: As noted.
5. Sensor:
   a. 316 Stainless Steel.
   b. Cable: Polyurethane outer jacket.
   c. Compression Seal: Silicone rubber.
   d. FE-1504 to be provided with 300 feet of sensor cable.
6. Transmitter:
   a. Enclosure Rating: IP67 aluminum die-cast.
   b. Configuration:
      1) Keypad programming.
      2) LCD display.
   c. Signal Interfaces:4-20 mA capable of driving load impedances up to 1,000 ohms.
7. Power Supply: 90-265V ac.
8. Manufacturer and Product: McCrometer Multi-Mag; Model 285L or equal.

G. L5 Level Element and Transmitter, Ultrasonic:

1. General:
   a. Function: Continuous, noncontacting level measurement.
   b. Type: Ultrasonic.
   c. Parts: Element, transmitter, interconnecting cable, and accessories as noted.
2. Service:
   a. Application: If and as noted.
   b. Vapor Space Pressure: Atmospheric, unless otherwise noted.
   c. Operating Temperature Range:
      1) Element: Minus 4 degrees F to plus 149 degrees F.
      2) Transmitter: Minus 4 degrees F to 113 degrees F.
3. Performance:
   a. Range: As noted.
   b. Zero Reference: As noted.
   c. Accuracy: Plus or minus 0.25 percent of maximum range or 6 mm, whichever is greater.
   d. Resolution: 0.1 percent of range or 2 mm, whichever is greater.
   e. Blanking Distance: Sensor dependent, typically 1 foot.
4. Element:
   a. NEMA 6P waterproof.
   b. Housing: PVDF, unless otherwise noted.

1) Other materials subject to Engineer approval.
c. Facing: None, unless otherwise noted
d. Integral Flange: If noted.
   1) Face: PTFE, unless otherwise noted.
   2) Size: As noted.
e. Process Connection:
   1) 1-inch NPT, unless otherwise noted.
   2) Top mounted.
f. Electrically Hazardous Rating:
   1) Class I, Div 1, Groups A, B, C, and D: If noted.
   2) Class II, Div 1, Groups E, F, and G: If noted.
   3) Other Ratings: As noted.
g. Beam Angle: 12 degrees or less.
h. Integral temperature compensation.

5. Transmitter:
   a. Display.
   b. Integral keypad or nonintrusive external programming.
   c. Enclosure: NEMA 4X polycarbonate, unless otherwise noted.
   d. Power Supply: 115 volts, 50/60-Hz, unless otherwise noted.
   e. Isolated Analog Output:
      1) One Minimum: 4 mA to 20 mA dc for load impedance of 0 to 750 ohms.
   f. Digital Communication: As noted.
   g. Discrete Outputs:
      1) Minimum, two relay (SPDT) rated for 2 amps continuous at 230V ac.
      2) Assignable and as noted.
6. Interconnecting Cable: Weatherproof, UV protected, length as required, and type as recommended by manufacturer.
7. Accessories:
   a. Submergence Shield: If noted.
   b. Remote Programming Software: If noted.
      1) Allows remote programming via computer and echo traces for troubleshooting.
      2) One per lot of units furnished.
   c. Others: As noted.
   d. If no integral keypad, furnish one handheld programmer per lot of units furnished.
8. Manufacturers and Products:
   a. Pulsar; Blackbox Series 13X and Sensor.
   b. Siemens; SITRANS L, Model HydroRanger 200 and Sensor.
   c. Endress & Hauser; Model FMU90 and Sensor.

H. L180 Leak Detector Switch, Electro-Optic:

1. General:
   a. Function:
      1) Monitor leak in such spaces as secondary containment and interstitial spaces.
      2) Switch.
   b. Type: Electro-optical level sensing.
   c. Parts: Sensor/switch and cabling.
2. Performance:
   a. Accuracy: Plus or minus 1 mm in water.
   b. Repeatability: Plus or minus 0.5 mm in water.
   c. Process Temperature: Minus 40 to 194 degrees F.
   d. Pressure: 150 psi (10 bar) at 25 degrees C.
3. Features:
   a. Sensor Material: PFA Teflon, unless otherwise noted.
   b. Sensor Length: Short (0.7-inch immersion length), unless otherwise noted.
4. Power: 12V dc to 36V dc.
5. Process Connection: 3/4-inch NPT, unless otherwise noted.
6. Signal Interface:
   a. Contacts:
      1) One SPST relay.
      2) Rating: 60 VA maximum.
      3) Suitable for either dc or ac connection.
7. Enclosure: NEMA 6/IP68, submersible.
8. Cabling:
   a. 10-foot length, five wires.
   b. Rating: NEMA 6/IP 68.
9. Manufacturer: Flowline, Switch-Tek, Optic Leak Detection Sensor, LO10 Series.

I. M4 Potentiometer, Oiltight:

1. General:
   a. Function: Adjust analog setpoint.
   b. Type: Heavy-duty, industrial, oiltight.
2. Performance:
   a. Resistance: 1,000 ohms, unless otherwise noted.
   b. Temperature, Operating: 32 to 131 degrees F.
   c. Humidity, Operating: 50 percent at 104 degrees F.
   d. Mechanical Design Life: 100,000 Cycles.
   e. Rated for 300V AC maximum.

3. Features:
   a. Mounting:
      1) 30.5 mm single round hole.
      2) Panel thickness:
         a) 1/16 to 3/16-inch.
         b) Counterboring required for thicknesses greater than 3/16-inch.
   b. Dial Plate:
      1) Standard size (46.4 H X 46.4 W, mm), unless otherwise noted.
      2) Aluminum field with black markings.
      3) Scale: 0 to 100 percent.
      4) Legend: As noted or shown.
   c. Depth: 2 inches, nominal.
4. Signal Interface: Three-wire.
5. NEMA Rating: 1/12/13.
6. Manufacturer:
   a. Allen Bradley, Bulletin 800T.
   b. Eaton Corp., Cutler-Hammer, Type 10250T.
   c. Square D Co., Class 9001, Type K.

J. M5 Hand Switch and Light, Oiltight, Square:

1. General:
   a. Function: Select, initiate, and display discrete control functions.
   b. Type: Heavy-duty, oiltight, industrial.
2. General Features:
   a. Dimensions: Approximately 1-1/2 inches square.
   b. Mounting: 30.5 mm single round hole. Panel thickness 1/16 inch to 1/4 inch.
   c. Configuration: Light, pushbutton, or switch arrangement as noted or shown.
3. Light Features:
   a. Lights: 6V ac lamps and integral transformer for operation from 120V ac, unless otherwise noted.
   b. Lens Color: Color as specified under PANEL, STANDARD LIGHT COLOR AND INSCRIPTIONS, or as noted.
4. Pushbutton and Switch Features:
   a. Operator: Pushbutton as noted. Black nonilluminated lever on switch, unless otherwise noted.
   b. Boot: None, unless otherwise noted.
5. Signal Interface:
   a. Contact Block:
      1) Type: Silver-coated butting, unless otherwise noted.

2) Rating: 10 amps continuous at 120V ac or as noted.
3) Sequence: Break-before-make, unless otherwise shown.
4) Arrangement: Normally open or normally closed as shown, or perform functions noted.
5) Terminals: Screw with strap clamp, unless otherwise noted.

6. NEMA Rating: NEMA 4, watertight and dusttight and NEMA 13, oiltight.
7. Manufacturers:
   a. Eaton Corp.; Cutler-Hammer, Type E30.
   b. Square D Co.; Class 9001, Type KX.

K. M12 Hand Switch and Light, Oiltight, Round:

1. General:
   a. Function: Select, initiate, and display discrete control functions.
   b. Type: Heavy-duty, oiltight, industrial.
2. General Features:
   a. Mounting: 30.5 mm single round hole. Panel thickness 1/16 inch to 1/4 inch.
   b. Legend Plate: Standard size square style aluminum field and black markings, unless otherwise noted. Markings as shown.
   c. Configuration: Light, pushbutton, or switch as noted or shown.
3. Light Features:
   a. Lights: 6V ac lamps and integral transformer for operation from 120V ac, unless otherwise noted.
   b. Lens Color: Color as specified under PANEL, STANDARD LIGHT COLOR AND INSCRIPTIONS, or as noted.
4. Pushbutton and Switch Features:
   a. Guard: Full guard with flush button, unless otherwise noted.
   b. Operator: Black pushbutton, black nonilluminated knob on switch, unless otherwise noted.
   c. Boot: None, unless otherwise noted.
5. Signal Interface:
   a. Contact Block:
      1) Type: Silver-coated butting, unless otherwise noted.
      2) Rating: 10 amps continuous at 120V ac or as noted.
      3) Sequence: Break-before-make, unless otherwise shown.
      4) Arrangement: Normally open or normally closed as shown, or perform functions noted.
      5) Terminals: Screw with strap clamp, unless otherwise noted.
6. NEMA Rating: NEMA 4, watertight and dusttight and NEMA 13, oiltight.

7. Manufacturers/Models:
   a. Allen-Bradley; Bulletin 800T.
   b. Eaton Corp.; Cutler-Hammer, Type 10250T.
   c. Square D Co.; Class 9001, Type K.

L. M26 Hand Switch and Light, Corrosion, Round:

1. General:
   a. Function: Select, initiate, and display discrete control functions.
   b. Type: Heavy-duty, corrosion-resistant, industrial.
2. General Features:
   a. Mounting: 30.5 mm single round hole. Panel thickness 1/16 inch to 1/4 inch.
   b. Legend Plate: Standard size, square style laminate with white field and black markings, unless otherwise noted. Markings as shown, or as implied by P&IDs.
   c. Configuration: Light, pushbutton, or switch as noted or shown.
3. Light Features:
   a. Lights: 6V ac lamps and integral transformer for operation for operation from 120V ac, unless otherwise noted.
   b. Lens Color: Color as specified, noted, or shown.
   c. Push-to-test, unless otherwise noted.
   d. Additional: As noted.
4. Pushbutton Features:
   a. Operator: Single pushbutton, flush, unless otherwise noted.
   b. Color: Black, unless otherwise noted.
   c. Boot: None, unless otherwise noted.
   d. Contact Arrangement: As required or shown.
   e. Additional: As noted.
5. Selector Switch Features:
   a. Operator: Knob, unless otherwise noted.
   b. Color: Black, unless otherwise noted.
   c. Boot: None, unless otherwise noted.
   d. Positions: As required or shown.
   e. Return: Manual, unless otherwise noted.
   f. Contact Arrangement: As required or shown.
   g. Additional: As noted.
6. Signal Interface:
   a. Contact Block:
      1) Type: Standard, unless otherwise noted.
      2) Materials: Silver amalgam, unless otherwise noted.
      3) Rating: 10 amps continuous at 120V ac, unless otherwise noted.

4) Sequence: Break-before-make, unless otherwise noted or shown.
5) Arrangement: Normally open or normally closed as shown, or to perform the functions noted.

7. NEMA Rating: NEMA 4, watertight, dust-tight, and NEMA 4X, corrosion-resistant.
8. Manufacturers and Products:
   a. Allen-Bradley; Bulletin 800H.
   b. Square D Co.; Class 9001, Type SK.
   c. Eaton Corp.; Cutler-Hammer, Type E34.

M. P3 Pressure Differential Transmitter:

1. General:
   a. Function:
      1) Measure differential pressure.
      2) Transmit signal proportional to either differential pressure or square root of differential pressure, as applicable.
   b. Type:
      1) Electronic variable capacitance or silicon strain gauge.
      2) Two-wire transmitter; "smart electronics".
   c. Parts: Transmitter and accessories.
2. Performance:
   a. Range: As noted.
      1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
   b. Accuracy: Plus or minus 0.10 percent of span, unless otherwise noted.
   c. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
   d. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
   e. Humidity: 0 to 100 percent relative humidity.
   f. Hazardous Location Certifications: If and as noted.
3. Features:
   a. Linear or square-root output, user-configurable.
   b. Factory preconfigure for square root output if transmitter tagged as "FT" or "FIT".
   c. Adjustable damping.
   d. LCD indicator, unless otherwise noted.
      1) Display in either percent or engineering units, field configurable.

e. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
    1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
f. Wetted O-Rings: Glass-filled TFE, graphite-filled PTFE, or Viton, unless otherwise noted.
g. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
h. Fill Fluid: Silicone, unless otherwise noted.

4. Process Connections:
    a. Line Size: 1/2 inch.
    b. Connection Type: FNPT.
    c. Direct/remote Diaphragm Seal: If and as noted.
5. Signal Interface:
    a. 4-20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
        1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
    b. FOUNDATION Fieldbus Protocol: If noted.
    c. Profibus: If noted.
6. Enclosure:
    a. Type: NEMA 4X.
    b. Materials: Coated aluminum, unless otherwise noted.
    c. Mounting bracket, unless otherwise noted.
        1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
7. Accessories:
    a. Three-valve manifold, unless otherwise noted.
        1) Includes one equalization and two isolation valves.
        2) Type 316 stainless steel.
8. Manufacturers and Products:
    a. Rosemount; Model 3051 CD.
    b. Foxboro; Model IDP10.
    c. SMAR; LD30XD Series.
    d. Endress Hauser.

N. P4 Pressure Gauge:

1. General:
    a. Function: Local pressure indication.
    b. Type: Bourdon tube element.
2. Performance:
    a. Scale Range: As noted.
    b. Accuracy: Plus or minus 0.50 percent of full scale.

3. Features:
    a. Dial: 4-1/2-inch diameter.
    b. Pointer Vibration Reduction: Required, unless otherwise noted. Use the following method.
        1) Liquid filled gauge front, unless otherwise noted.
            a) Glycerine fill, unless otherwise noted.
    c. Case Material: Black thermoplastic, unless otherwise noted.
    d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
        1) Stainless steel, unless otherwise noted.
    e. Pointer: Adjustable by removing ring and window.
    f. Window: Glass or acrylic, unless otherwise noted.
    g. Threaded reinforced polypropylene front ring.
    h. Case Type: Solid front with blow-out back.
4. Process Connection:
    a. Mounting: Lower stem, unless otherwise noted.
    b. Size: 1/2-inch MNPT, unless otherwise noted.
5. Accessories:
    a. Throttling Device: Required, unless otherwise noted.
        1) Type suitable for the intended service.
        2) Install in gauge socket bore.
6. Manufacturers and Products:
    a. Ashcroft; Duragauge Model 1259/Model, 1279/Model, 1279 PLUS!
    b. Ametek U.S. Gauge; Solfrunt Model 19XX/1981Advantatge.
    c. WIKA, Type 2XX.34.

O. P6 Pressure Seal, Diaphragm:

1. General:
    a. Function: Isolate sensing element from process fluid.
    b. Type:
        1) Diaphragm.
        2) Fluid filled between diaphragm and sensing element.
2. Service:
    a. Pressure: Same as associated sensor.
    b. Temperature Range: If noted.
3. Performance:
    a. Pressure:
        1) For threaded process connections, at least 2,500 psig at 100 degrees F.
        2) Glycerin Fill: Suitable only for pressure (not vacuum applications).

b. Temperature:
   1) Dependent upon fill fluid.
      a) Glycerin (food grade): Zero to 400 degrees F.
      b) Silicone: Minus 40 degrees F to plus 600 degrees F.
      c) Silicone (food grade): Zero to 375 degrees F.
      d) Halocarbon: Minus 70 degrees F to 300 degrees F.

4. Features:
   a. Materials:
      1) Lower Housing: Type 316 stainless steel, unless otherwise noted.
      2) Diaphragm Material: Type 316 stainless steel, unless otherwise noted.
      3) Top Housing: Steel, unless otherwise noted.
   b. Diaphragm: Welded to upper housing, unless otherwise noted.
   c. Filling screw in upper housing.
   d. Fill Fluid:
      1) As noted.
      2) Or approved equal.
      3) Factory assembled and filled.
   e. Flushing Connection: 1/4-inch NPT in lower housing.
   f. Diaphragm Seal Displacement: 0.1 cubic inch, nominal.
5. Connections:
   a. Instrument: 1/2-inch female NPT, unless otherwise noted or shown.
   b. Process: 1/2-inch female NPT, unless otherwise noted or shown.
6. Manufacturers:
   a. Ashcroft; Type 201.
   b. Ametek; Mansfield and Green Division; Type SG.
   c. WIKA; Type L990.10.

P. P7 Pressure Switch, Adjustable Dead Band:

1. General:
   a. Function: Monitor pressure, activate switch at setpoint, and deactivate switch at reset point.
   b. Type:
      1) Piston-actuated.
      2) Both setpoint and deadband (the differential between setpoint and reset point) adjustable.
2. Performance:
   a. Setpoint:
      1) As noted.
      2) Repeatability: Plus or minus 1 percent of range.
   b. Reset Point: As noted.

c. Range: The noted setpoint shall fall between 20 percent and 80 percent of the range.
d. Deadband: Adjustable within nominally 25 percent and 85 percent of range.
e. Overpressure Proof Pressure:
    1) Pressure psi Ranges: At least 400 percent of rated maximum static pressure.
    2) Pressure Inches of Water Ranges: 20 psig.
    3) Compound Range: 250 psig.
    4) Vacuum Range: 250 psig.
f. Operating Temperature Range:
    1) Dependent on actuator seal materials.
    2) For Buna-N seal, 0 degrees F to 150 degrees F.

3. Features:
    a. Actuator Seal: Buna-N, unless otherwise noted.
    b. Adjustable deadband.
    c. Mounting: Surface, unless otherwise noted.
4. Process Connection:
    a. 1/4-inch NPT female connections, unless otherwise noted.
    b. Materials:
        1) Pressure psi Ranges: Type 316 stainless steel, unless otherwise noted.
        2) Pressure Inches of Water Ranges: Epoxy coated carbon steel, unless otherwise noted.
5. Enclosure: NEMA 4X, unless otherwise noted.
6. Signal Interface:
    a. Contact Type:
        1) SPDT.
        2) Rated for 10 amps minimum at 120V ac.
    b. Hermetically Sealed Switch: If noted.
7. Manufacturers and Products:
    a. Ashcroft; L or P Series.
    b. United Electric; J6 Series.
    c. If NEMA 7, explosion-proof enclosure specified; Ashcroft; P Series only.

Q. P9 Pressure Transmitter:

1. General:
    a. Function: Measure pressure and transmit signal proportional to pressure.
    b. Type:
        1) Electronic variable capacitance or silicon strain gauge.
        2) Two-wire transmitter; “smart electronics”.

   c. Parts: Transmitter and accessories.
2. Performance:
   a. Range: As noted.
      1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
   b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
   c. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
   d. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
   e. Humidity: 0 to 100 percent relative humidity.
   f. Hazardous Location Certifications: If and as noted.
3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Adjustable damping.
   c. LCD indicator, unless otherwise noted.
      1) Display in either percent or engineering units, field configurable.
   d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
      1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
   e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
   f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
   g. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
   a. Line Size: 1/2 inch.
   b. Connection Type: FNPT.
   c. Direct/remote Diaphragm Seal: If and as noted.
5. Signal Interface:
   a. 4-20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
      1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
   b. FOUNDATION fieldbus protocol: If noted.
   c. Profibus: If noted.
6. Enclosure:
   a. Type: NEMA 4X.
   b. Materials: Coated aluminum, unless otherwise noted.

c. Mounting bracket, unless otherwise noted.
   1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.

7. Accessories:
   a. Two-valve (isolate and vent) Stainless Steel Manifold: If noted.
8. Manufacturers and Products:
   a. Gauge Pressure Units:
      1) Rosemount; Model 3051 TG.
      2) Foxboro; Model IGP20.
      3) SMAR; LD30XM Series.
      4) Endress Hauser.
   b. Absolute Pressure Units:
      1) Rosemount; Model 3051 TA.
      2) Foxboro; Model IAP20.
      3) Endress Hauser.

R. T5 Temperature Switch:

1. General:
   a. Function: Provide change in contacts as temperature rises or falls through noted setpoint.
   b. Type:
      1) Vapor pressure thermal bulb sensing element.
      2) Fixed differential, unless otherwise noted.
   c. Parts: Switch/element assembly and thermowell.
2. Performance:
   a. Setpoint: As noted.
   b. Range: Such that noted setpoint falls between 30 percent and 70 percent of range.
   c. Repeatability: Plus or minus 1 percent of span.
3. Switch:
   a. Type: Snap action, SPDT, sealed environmental proof, unless otherwise noted.
   b. Rating: 125V ac 15A, unless otherwise noted.
   c. Reset: Automatic.
   d. Enclosure:
      1) Type: NEMA 4X, unless otherwise noted.
      2) Mounting:
         a) Direct mount, unless otherwise noted.
         b) If remote mounted, furnish capillary with length either as noted or as required.
4. Element:
   a. Type: Bulb.
   b. Stem mounted to thermowell.

c. Length: Coordinate with thermowell insertion length.
5. Thermowell:
    a. Process Connection: 1/2-inch NPT(M).
    b. Material: Type 316 stainless steel or Type 304 stainless steel.
    c. Insertion Length: 3-1/2 inch minimum immersion for liquids and 5-1/2 inch minimum immersion for gases, unless otherwise noted.
6. Electrical Connections:
    a. Conduit: 1/2-inch NPT(F).
7. Manufacturers:
    a. Ashcroft; B Series (Type 400 NEMA 4X, Type 700 NEMA 7 and NEMA 9).
    b. Barksdale; ML1H, MT1H.

S. T9 Thermometer, Adjustable Angle:

1. General:
    a. Function: Indicate process temperature.
    b. Type: Mercury, adjustable angle.
    c. Parts: Thermometer and thermowell.
2. Performance:
    a. Scale Range: As noted.
    b. Accuracy: Plus or minus 1 percent of scale.
3. Thermometer Features:
    a. Stem:
        1) Aluminum.
        2) Length: 3-1/2 inch, unless otherwise noted.
        3) Adjustable: Lockable in any position through a 180 degree arc.
    b. Scale:
        1) Dual: Fahrenheit and Centigrade.
        2) Length: 9 inches.
    c. Indicating Column: Red-reading, memory filled magnifying lens.
    d. Case: Nylon, glass-fiber reinforced.
    e. Window: Heavy glass.
4. Thermowell:
    a. Separable from thermometer.
    b. Materials: Type 304 stainless steel, unless otherwise noted.
    c. Process Connection: 3/4-inch NPT, unless otherwise noted.
    d. Extension Neck: None, unless otherwise noted.
5. Manufacturers and Products:
    a. Marsh Instruments, Marsh-Bellofram; Series Y Adjustable Themometer.
    b. Ametek, U.S. Gauge Div.; Series T571 Glass Tube Thermometer.

T. Y50 Programmable Logic Controller System:

1. General:
   a. Function: Used for process monitoring and control by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.
   b. Type: Microprocessor based device programmable using ladder logic.
   c. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference PLC system block diagram in Drawings.
2. Environmental:
   a. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).
   b. Humidity: Operating range 5 to 95 percent noncondensing.
   c. Vibration:
      1) Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10-to 57-Hz; 1 g, 57- to 150-Hz.
      2) Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.
   d. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B.
   e. Isolation: User-side to PLC side 1,500V rms.
3. Central Processing Unit (CPU):
   a. Type: Microprocessor, 16-bit minimum.
   b. Scan Time: Less than 1 ms/K words of relay ladder logic.
   c. PLC Communications:
      1) Two communication ports, RS-232 and RS-422. RS-232.
      2) One I/O port.
      3) Baud rates supported 1200, 2400, 9600, 19200.
   d. Instruction Set:
      1) Timers and Counters: Quantity 1,024, minimum; minimum timer resolution 0.1 seconds; minimum counter count range 0 to 32,000.
      2) Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
      3) Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.

4) Process Loop Control: User configurable direct or reverse acting PID loop control computation with the capability of both AUTO and MANUAL modes of operation, remote access to controller tuning constants; minimum of [**A**: **64**] PID loops.
5) Real Time Clock: Date and time set and compare.
6) Miscellaneous: Jump or skip to a label, quantity 255; one shot, quantity 1,024; drums, quantity 64; preconfigured analog alarm functions, quantity 128; subroutines, quantity 128.

e. Diagnostics:
1) Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status and primary PLC state for redundant PLC systems.
2) Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
3) Power Up: PLC checks status of PROMs upon powerup; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
4) Diagnostic Tables: Tables, displayable by programming computer, that describe nature and location (address) existing faults and errors.

f. Agency Approvals and Standards:
1) UL listed.
2) CSA certified.
3) DIN Standard 41494.
4) IEC-65A/WG6 draft proposal.
5) Factory Mutual approved.

4. Random Access Memory (RAM):
a. Type: CMOS type.
b. Word Size: 16 bits, minimum.
c. Battery Backup: 6 months, minimum.
d. Memory Size: Sufficient to implement all applications software plus 100 percent spare.
e. Memory Size: 32 K words of ladder logic memory, 8 K words of variable memory, plus required overhead for standard functions.
f. Read only memory (ROM) for controller's operating system and diagnostics.
g. Memory Protection: Keylock switch.

5. Power Supply: One unit for each input/output base assembly:
a. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output.
b. Mounting: Internal to base.

6. Input/Output: Complete input/output system, including remote I/O with distances up to 5,000 feet minimum; a minimum of 1,024 I/O points in up to 15 remote I/O racks.
   a. Discrete Input Modules:
      1) Voltage: 120 volts, 60-Hz.
      2) Operating Power: 2 watts.
      3) Points per Module: 16, maximum.
      4) LED status indicator for each point.
      5) Isolation: Between input point and PLC, 1,500 volts rms.
   b. Discrete Output Modules:
      1) Voltage: 120 volts, 60-Hz.
      2) Operating Power: 2 watts.
      3) Load Rating: 2 amps continuous.
      4) Isolation: Between PLC and output point, 1,500 volts rms.
      5) Points per Module: 16, maximum.
      6) LED status indicator for each point.
   c. Isolated Discrete Output Modules:
      1) Type: Isolated Form C relay.
      2) Voltage: 120 volts, 60-Hz.
      3) Isolated Outputs per Module:8. Load Rating: 5 amps continuous.
      4) Operating Power: 2.5 watts.
      5) Points Per Module: 8,[maximum.
      6) LED status indicator and fuse for each point.
      7) Isolation: Between PLC and output point, 1,500 volts rms.
      8) Manufacturers: Allen-Bradley,
   d. Analog Input/Output Modules:
      1) Voltage: 24 volts dc.
      2) Power: 3 watts.
      3) Differential Analog Points Per Module: 8, maximum.
      4) Isolated Analog Output Points Per Module: 8,maximum.
      5) Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
      6) Analog Input Resolution: 12 bits.
      7) Analog Output Resolution: 12 bits.
7. Remote Input/Output Bases:
   a. Power Supply: Same power supply as described in subparagraph Power Supply, above.
   b. Base Controller: One remote I/O adapter module required for each remote base.
   c. Slots: The base shall have 8 slots for input/output modules.
8. Communication Network:
   a. Allen-Bradley DeviceNet.
   b. ETHERNET.

9. Identification:
   a. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply.).
   b. Label configured I/O points as they have been configured (addressed) in the system, as approved by the Engineer.
10. Spares:
   a. Spare I/O Cards Installed in I/O racks: For each type of I/O card, quantity =10 percent of each type and size used, minimum 1 each.
   b. Spare I/O Cards Provided Loose (Shelf Spares): For each type of I/O card, quantity = 10 percent of each type and size used, minimum 1 each.
   c. Power supply 1 each of each type and size used, minimum 1 each.
   d. Cables.
   e. Data Highway Card: 1.
   f. Communication Module: 1.
11. Manufacturers and Products:
   a. Allen-Bradley; Model ControlLogix.

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 95 80
FIBER OPTIC COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Institute of Electrical & Electronic Engineers, Inc. (IEEE): 802.3, Telecommunication and Information Exchange Between Systems.
2. International Organization for Standardization (ISO).
3. National Electrical Code (NEC).
4. Telecommunications Industry Association (TIA); Electronics Industry Association (EIA):
   a. 492, Specifications for Optical Waveguide Fibers.
   b. 568, Commercial Building Telecommunications Cabling Standard.
   c. 569, Commercial Building Standards for Telecommunications Pathways and Spaces.
   d. 607, Commercial Building Grounding and Bonding Requirements for Telecommunications.

1.02 ABBREVIATIONS

A. ATM: asynchronous transfer mode.

B. AUI: attachment unit interface.

C. dB decibel.

D. DNI: desktop network interface.

E. FDDI: fiber distributed data interface.

F. FIM: Facilities Information Management.

G. FOCS: Fiber Optic Communication Subsystem.

H. FOIRL: Fiber Optic Inter Repeater Link.

I. LAN: local area network.

J. LIMS: Laboratory Information Management System.

K. MHz: megahertz.

L. micro: x 10^{-6}.

M. MIS: Management Information System.

N. Mbps: megabits per second.

O. N: newton.

P. n, nano: x 10^{-9}.

Q. nm: nanometer.

R. OTDR: optical time-domain reflectometer.

S. PIC: Process Instrumentation and Control.

T. μm: micrometer.

U. UPS: uninterruptible power supply.

V. V ac: volts alternating current.

W. WAN: wide area network.

1.03 SYSTEM DESCRIPTION

A. This section covers requirements for Fiber Optic Communication Subsystem (FOCS) and is in addition to Section 40 90 00, Instrumentation and Control for Process Systems.

B. Function of FOCS is to transmit digital data between network nodes. Requirements listed identify minimum acceptable system performance.

C. Provide a FOCS based on referenced standards for use in the following local and wide area networks:

1. Ethernet.

D. Network(s) will be used by PIC to distribute data and coordinate Owner's operations.

1.04 SUBMITTALS

A. Action Submittals:

1. Site layout diagram showing:
   a. Access holes, with identification.
   b. Above grade cable routings, with pole and cable identification.
   c. Below grade conduit routings between access holes and buildings, with conduit counts and identification.
   d. Below grade innerduct routings through conduits, with innerduct counts and identification.
   e. Cable routings through innerducts and to patch panels, fiber centers, or network nodes, with cable and node identification.
2. Cable schedule showing:
   a. Cable identification.
   b. Fiber counts for each cable and identification of used fiber pairs.
   c. Cable length and attenuation, with 2 connector pairs and no planned number of 1 splices, based on TIA/EIA 568, Annex H.
3. Component Data:
   a. Manufacturer and model number.
   b. General data and description.
   c. Engineering specifications and data sheet.
   d. Scaled drawings and mounting arrangements.

B. Informational Submittals:

1. Manufacturer's statement that installer is certified to perform installation Work.
2. Subcontractor Qualifications:
   a. FOCS Subcontractor: Minimum of 5 years' experience providing, integrating, installing, and commissioning of similar systems.
   b. FOCS Subcontractor's Site Representative: Minimum of 5 years' experience installing similar systems.
   c. Owner acceptance of FOCS Subcontractor does not exempt FOCS Subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.
      1) Statement of Experience: List of at least 3 fiber optic data communications systems comparable to system specified which have been furnished and placed into operation by prospective FOCS Subcontractor. For each system, provide following information:
         a) Owner's name, address, telephone number, and name of current operations supervisor or other contact.

b) Description of system hardware configuration, including major equipment items, number of nodes, and communication standards implemented.
c) System block diagram.
d) Dates when contract was signed, equipment was delivered, and system was accepted by Owner. Also, include originally scheduled completion date and if different from actual date, explain why.
e) Approximate value of listed FOCS provided in dollars.

2) Qualification of Personnel:
a) Resumes giving management and technical qualifications of supervisory, local service representative, and key personnel.
b) For each maintenance organization, identify location of base of service and how required coverage will be achieved.

3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
4. Manufacturer's suggested installation practice.
5. Testing related submittals.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable and Cable Splice Centers:

1. Outside, Underground/Submerged: Minus 20 to 40 degrees C.
2. Outside, Overhead: Minus 40 to 80 degrees C.
3. Outside, Aboveground in Conduit: Minus 40 to 80 degrees C.
4. Inside: 0 to 40 degrees C.

B. Equipment:

1. Outside, Aboveground: Minus 40 to 80 degrees C.
2. Control Rooms, Equipment Rooms and Telecommunications Closets: 30 to 55 percent relative humidity, 18 to 24 degrees C.
3. Other Interior Areas: 0 to 100 percent relative humidity, 5 to 35 degrees C.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Jumpers of each length needed	XX complete set

PART 2 PRODUCTS

2.01 MATERIALS

A. Fiber Optic Cable:

1. Fiber Characteristics: Single-Mode.
   a. Comply with TIA/EIA 568.
   b. 8.3/125 μm glass single-mode.
   c. Tight-buffered, 900 μm buffer:
      1) Inner buffer: Acrylate, UV-cured, soft.
      2) Outer buffer: PVC, elastomeric, hard.
   d. Maximum Attenuation: 1300/1550 nm: 1.0 dB/km.
   e. Color-coded buffer.
   f. Minimum Bend Radius, Buffered Fiber: 1 inch.
   g. Proof Testing: 100 kpsi.
2. Fiber Characteristics: Multimode
   a. Comply with TIA/EIA 568.
   b. 62.5/125 μm graded-index glass.
   c. Tight-Buffered, 900 μm buffer:
      1) Inner buffer: Acrylate, UV-cured, soft.
      2) Outer buffer: PVC, elastomeric, hard.
   d. Maximum Attenuation:
      1) 850 nm: 3.0 dB/km.
      2) 1300 nm: 1.0 dB/km.
   e. Minimum Bandwidth:
      1) 850 nm: 200 MHz-km.
      2) 1300 nm: 500 MHz-km.
   f. Color-coded buffer.
   g. Minimum Bend Radius, Buffered Fiber: 1 inch.
   h. Proof Testing: 100 kpsi.
3. Cable:
   a. Fiber Count:
      1) Single-mode: 12 fibers per cable, minimum.
      2) Multimode: 12 fibers per cable, minimum.

b. All Dielectric Construction: No electrically conductive components in fiber optic cable are allowed.
c. Helically Wound: Buffered fibers helically wound; approximately 5 turns per meter.
d. Gel-Free: Fibers tight-buffered, not in gel-filled loose-tube.
e. Core-Locked with no separator tape.
f. Style: Break-out.
g. Strength Member:
    1) Nonconductive; integral part of cable; supports stress of installation and load during use.
    2) Fiberglass epoxy rod, aramid fiber, kevlar.
    3) Minimum Tensile Strength: 600 pounds.
h. Protective Covering:
    1) Polyvinylchloride (PVC); riser rated.
    2) Continuous and free from holes, splices, blisters, and other imperfections.
i. Minimum Bend Radius:
    1) Short-term Under Tension: 20 times cable diameter.
    2) Long-term Without Tension: 15 times cable diameter.
j. Identification:
    1) Identify with tags shown and in accordance with Section 40 90 00, Instrumentation and Control for Process Systems.
    2) Use waterproof tags and identifications.
k. Manufacturer: Optical Cable Corporation.

B. Innerduct:

1. Multicell conduit system designed for fiber optic cabling and telecommunications.
    a. Features:
        1) Outerduct, complete with innerducts preinstalled.
        2) Innerduct identification system.
        3) Gasketing that allows watertight assembly and disassembly of outer and innerducts for direct buried and encased installations.
        4) Couplings, access hole terminators, innerduct seals for both empty and cabled ducts, and fixed and flexible bends.
2. Outerduct (conduit located outside innerduct):
    a. Industry Standard: 100 mm duct with integral bell end.
    b. Material: PVC 'C' duct, 3.8 mm wall.
    c. Marking: Indicates proper innerduct orientation and alignment.
    d. Length: 6 meter lay.

3. Innerduct:
    a. Size and Count: 30 mm; 4.
    b. Material: Smoothwall PVC.
    c. Lubrication: Prelubricated with atomized silicone lubricant.
4. Manufacturer and Product: Carlon; Multi-Gard.

C. Innerduct:

1. Function: Installs into conduit system provided by others, to provide smooth, low-friction path through conduit, with only one cable per path to facilitate changing individual cables.
2. Features:
    a. Size and Count, in 4-inch conduit: 19 mm; 4.
    b. Type: Annular, corrugated innerduct.
    c. Material: HDPE.
    d. Color: Color code innderducts Orange, Blue, Green, Brown, White, or Grey.
    e. Strength: Minimum 600 pounds tensile strength, with no more than 5 percent ovalization at 600 pounds tension.
    f. Lubrication: Prelubricated.
3. Manufacturers:
    a. Endocor.
    b. Dura-Line.

D. Ethernet Fiber Optic Repeaters:

1. Function: Extends Ethernet communications range beyond 1,000 meters.
2. Features:
    a. Complies with IEEE 802.3 specification and FOIRL.
    b. Attaches into Ethernet segment and repeats signals bidirectionally.
        1) Regeneration: Regenerative repeater retimes packets, regenerates preamble, extends collision fragments, partitions problem segments and reconnects nonproblem segments.
        2) Media: Support fiber optic type specified.
        3) Wavelength: 850 nm.
        4) Fiber Optic Connectors: ST.
    c. Mounting: Stackable in 19-inch rack.
    d. Power: 120V ac.
3. Segments per Repeater, Maximum: 1.
4. Manufacturers and Products:
    a. Black Box:
        1) For 100Base-FX: Model LB6540.

2) For 10Base-FL: Model LE4207A-R3 with ST connectors; Model LE4207A-SC with SC connections, and Model LE4307A-ST/SC with one of each type of connector.

b. Hewlett-Packard.
c. Newbridge.
d. 3Com.

E. Ethernet Fiber-To-Copper Transceivers:

1. Function: Convert fiber optic Ethernet signal (10Base-FL) to copper signal.
2. Features:
   a. Support fiber optic type specified.
   b. Fiber Optic Connectors: ST.
   c. Copper Connector: BNC.
   d. Power:
      1) Powered by signal, or
      2) 120V ac.
   e. Mounting: Suitable for permanent mounting.
3. Manufacturers and Products:
   a. ATI Centre; COM MX40F/ST.
   b. Hewlett-Packard.
   c. Black Box.

F. Fiber Distribution Frame:

1. Function: Provides industry-standard rack mounting system for interface between fiber optic backbone and equipment cables.
2. Features:
   a. Used in either cross-connect or interconnect configuration.
   b. 23-inch rack for mounting 19-inch rack mount units.
      1) Accommodates up to 576 fiber terminations per frame.
      2) Accepts connector module housing and splice housing within same rack.
      3) Fiber Optic Connectors: ST.
   c. Fiber/Wire Management System:
      1) Vertical: 3-inch by 4-inch supports on 8-inch centers vertically on four sides (front LHS, back LHS, front RHS, back RHS).
      2) Horizontal: Supports on 4-inch centers horizontally above and below each termination frame front and back. Support may serve frames immediately above and below.
   d. Mounting Hardware: Accepts standard 19-inch rack for integrated fiber optic system (i.e. hubs, routers, patch panels, etc.).

e. Splice Trays with Coil Former: Former to wind slack cable around, provides controlled long radius bends.
    1) Doors: Pivot down lockable.
    2) Foot and End Caps: Included in final, assembled unit.
    3) Ancillaries: Jumper troughs and covers, cable tie brackets.

3. Manufacturers:
    a. Ortronics.
    b. Siecor.

G. Fiber Centers:

1. Function: Provides a secure place to terminate fiber optic cables.
2. Features:
    a. Compartments: Two; one for fiber optic cable, one for jumpers to individual equipment.
    b. Coil Former: Former to wind slack cable. Provides controlled long-radius bends.
    c. Connectors: Minimum 24 ST connectors for entry and exit.
    d. Size: Maximum 18 inches by 12 inches by 4 inches.
    e. Construction: 1.5-millimeter steel with noncorrosive finish.
    f. Mountings: Suitable for permanent attachment as shown, or provide separate mountings that do not obscure covers and doors.
    g. Doors: Separate doors for cable and jumper terminations and lockable.
3. Manufacturers and Products:
    a. Ortronics; OR-615SMFC.
    b. AT&T.
    c. Siecor.

H. Splice Housings

1. Function: House splices and serve as pulling box.
2. Features:
    a. Size: In accordance with TIA/EIA 569, Table 4.4-2.
    b. Mounting: Suitable for standard 19-inch rack or wall mounting.
    c. Environment: Equipment room.
    d. Enclosure: Epoxy-coated steel with hinged cover.
3. Manufacturers and Products:
    a. Siecor; FSC.
    b. AMP; 5025 Series.

I. Connectors

1. Features:
    a. In accordance with requirements of TIA/EIA 568, Section 12.4.3 or Annex F.
    b. ST connectors with 12.7 millimeter spacing between ferrules.
    c. Pull Strength: 0.2 N minimum.
    d. Durability: Sustain minimum 500 mating cycles without violating other requirements.
        1) Ferrules: Free-floating low loss ceramic.
        2) Polarizing key on duplex connector systems.
2. Quantity: Connectorize fibers, minimum per cable:
    a. Multimode: As shown on Drawings.
3. Attenuation:
    a. In accordance with requirements of TIA/EIA 568, Section 12.4.4.
    b. Maximum of 0.75 dB per connector pair.
4. Manufacturer: AMP.

J. Jumper Cables:

1. In accordance with requirements of TIA/EIA 568, Section 12.5.
2. Function: To connect from fiber centers to network nodes, such as computer workstations.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Cable Configuration:
    a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
    b. Protected with kevlar strength members and enclosed in thermoplastic jacket.
5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors:
    a. As required by Article Connectors.
    b. On-axial Pull Strength: 33 N.
    c. Normal-to-Axial Pull Strength: 22 N.
7. Communications Management Outlets:
    a. In accordance with TIA/EIA 568, Section 12.4.5.
    b. Function: Provide organized system for connecting workstations into precabled communications.
    c. Cover Plates:
        1) Flush and extension mount, as required to provide bend radius and space for coiled cable.
        2) Materials: ABS plastic.

3) Color: White, unless otherwise indicated.
4) Identifiers: Color-coded identification strips preprinted as shown.

d. Connectors:
1) ST connectors, counts as shown.
a) Single-mode: SC.
b) Multimode: ST.
2) Sleeves: Phosphor bronze.
3) Mounting: Face.

e. Manufacturers and Products:
1) Ortronics; Series II.
2) AMP; Fixed Shroud Duplex (FSD) System.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduits are provided under Division 26, Electrical.

1. Ensure that installed conduit system conforms to fiber optic system requirements, including:
   a. Conduits and Innerducts: Size and number.
   b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts can be installed without exceeding manufacturer's limitations.
   c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.
2. Spare Conduits:
   a. No cables shall be pulled into spare conduits.
   b. 100 percent spare conduit capacity required for all buried conduits only, i.e., for every conduit with one or more cables in it, there shall be one spare equal-size conduit with no cables.
   c. Spare conduits need not have innerduct installed.
3. Expansion Plugs: Seal conduits to stop ingress of water and grit with fabricated expansion plugs.

B. Innerduct:

1. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
2. Empty Innerducts: Seal empty innerducts immediately after installation to stop ingress of water and grit with fabricated expansion plugs. Remove plugs as required to install cables.

C. Innerduct:

1. Installation:
   a. In accordance with manufacturer's recommendations.
   b. Color Code: Install no more than one innerduct of each color in single conduit.
   c. Terminations: Terminate innerducts in conduit with fabricated termination kits.
2. Sealing:
   a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
   b. Empty Innerducts: Seal empty innerducts immediately after installation to stop ingress of water and grit with fabricated expansion plugs. Remove plugs as required to install cables.
   c. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.
3. Identification: Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall

D. Fiber Optic Cable:

1. Installation by manufacturer certified installer.
2. Install cables in accordance with manufacturer's requirements
3. Install cable directly from shipping reels. Ensure that cable is not:
   a. Dented, nicked, or kinked.
   b. Subjected to pull stress greater, or bend radius less, than manufacturer's specification.
   c. Subjected to treatment that may damage fiber strands during installation.
4. Cables Per Conduit or Innerduct: One cable maximum.
5. If calculation indicates that cable will attenuate signals more than 8 dB, reroute may be allowed, if approved by Engineer.
6. Splices: Install fiber optic cables in unspliced lengths from fiber centers to switches or hubs.
7. Identification: Identify cable on both ends and in access holes and pull points it goes through.
8. Sealing: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion plugs.
9. Access Holes:
   a. Provide supports for cables in access and handholes at minimum600 mm.
   b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

E. Fiber Centers:

1. Install securely in field panels as shown.
2. Minimum, one per facility having one or more network nodes.

F. Cable Terminations:

1. Terminate cables in accordance with TIA/EIA 568.
2. Slack:
   a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
   b. Communications Management Outlets: Minimum, 1-meter slack fiber, coiled neatly in outlet box.
3. Connectors:
   a. Terminate minimum 12 fibers in each cable to specified connectors.
   b. Connect into fiber management system.

G. Ethernet Fiber-to-Copper Transceivers:

1. Install transceivers in accordance with manufacturer's instructions.
2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.
3. Power: Energize each transceiver from its field panel's UPS, if applicable.
4. Connections:
   a. Connect transceiver to fiber optics and network node.
   b. Lace fiber optics neatly in place, routed through wireways.

3.02 FIELD QUALITY CONTROL

A. Test components of installation in accordance with standards and specifications.

B. Provide equipment, instrumentation, supplies and skilled staff necessary to perform testing.

C. Advise Engineer at least 24 hours in advance of each test. Engineer shall have option to witness and participate actively in tests.

D. Document test results of each cable to confirm that at least specified number of fibers meet standards, in accordance with Supplement titled As-Built Fiber Optic Cable Installation.

E. For each conduit and innerduct, complete As-Built Conduit/ Innerduct Installation form included as Supplement to this section.

F. Document results of repeater and transceiver tests.

3.03 TESTS AND INSPECTION

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Conduit:

1. Testing and Sealing of Spare Conduits.
2. Conduit and Innerduct Testing:
   a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
   b. If any conduit is not unrestricted over full length, advise Engineer.
3. Documentation: Confirm that conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

C. Cable Testing:

1. TIA/EIA 568: Demonstrate that minimum 12 fibers in each cable meet requirements of TIA/EIA 568, Annex H
   a. Maximum attenuation as specified in Part II, Fiber Optic Cable.
   b. Measure attenuation in both directions, not in one direction only.
   c. For multimode fibers only: Measure attenuation at both 850 nm and 1,300 nm.
2. Replace and retest cables that do not have specified number of fibers that meet attenuation standards.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. One person-days for installation assistance and inspection.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 SUPPLEMENTS

A. Supplements listed below, following "End of Section," are part of this Specification.

1. As-Built Conduit/Innerduct Installation Form.

END OF SECTION

Project: **(Include your project's name here)**

Contractor:

Signed by:

AS-BUILT CONDUIT/INNERDUCT INSTALLATION

From: To:

(Identify building, access hole, field panel, etc.) Sheet 1 of 1

Conduits:
Used: 4 inches; 2 inches
Spare: 4 inches; 2 inches Confirm all spares unrestricted: Yes/No
(Provide number of conduits in each category)

Innerducts:

Conduit ID*	Innerduct ID	Cable ID / Spare

(Continued overleaf delete if not applicable)

*Provide conduit ID if required to identify innerduct uniquely in the access hole, if for example, color-coded innerduct is used in more than one conduit. If innerducts are tagged uniquely, leave this column blank.

END OF SUPPLEMENT

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SECTION 41 22 13.13
OVERHEAD CRANES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist).
   b. B30.10, Hooks.
   c. B30.11, Monorails and Underhung Cranes.
   d. B30.17, Overhead and Gantry Cranes (Top Running, Single Girder).
   e. HST 1M, Performance Standard for Electric Chain Hoists.
   f. HST 2M, Performance Standard for Hand Chain Manually Operated Chain Hoists.
   g. HST 4M, Overhead Electric Wire Rope Hoists.
2. Crane Manufacturer's Association of America (CMAA):
   a. 70, Electric Overhead Traveling Cranes.
   b. 74, Top Running & Under Running Single Girder. Electric Overhead Traveling Cranes.
3. National Electrical Manufacturer's Association (NEMA):
   a. MG 1, Motors and Generators.
   b. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Occupational Safety and Health Act (OSHA).
6. Underwriters Laboratory (UL): 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.02 DESIGN REQUIREMENTS

A. Top-Running and Underhung Single-Girder Overhead Traveling Cranes: CMAA No. 74, and ASME B30.11.

B. Crane Service Class: CMAA No. 74.

C. Trolley Service Class: CMAA No. 70.

D. Wire Rope Hoist Service Class: ASME HST 4M and CMAA No. 70 or No. 74.

E. Chain Hoist Service Class: ASME HST 1M and CMAA No. 70 or No. 74.

F. Hook: ASME 30.10.

G. Building Clearances: CMAA No. 70 and No. 74. Where bridge span exceeds 40 feet, increase clearance to 6 inches.

H. Stress and Safety Factors: CMAA No. 70 and No. 74. Properly select materials of construction for stresses to which subjected.

I. Safety of Operation, Accessibility, Interchangeability, and Durability of Parts: ASME B30.2.0 and OSHA requirements. Design equipment for environment operated.

J. Provide system, equipment, and components, including supports and anchorages, designed in accordance with Section 01 61 00, Common Product Requirements.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, lifting capacity and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, materials of construction, and specifications on bridge drive system, end trucks, footwalks and platforms, wheels, shafting, drive motor, gears and bearing, steel framing, trolley drive system, hoist motor and assemblies, hook, brakes, starting system, variable speed drive system, conductors (bus bar, festoon, cable reel), controls, remote control system, and accessories.
   c. Power and control wiring diagrams, including terminals and numbers.
   d. Motor nameplate data in accordance with NEMA MG 1 and include any motor modifications.
   e. Factory finish system.

B. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer's printed installation instructions.
3. Factory Functional Test Report.

4. Suggested spare parts list to maintain the equipment in service for a period of 3 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Maximum95 degrees F; minimum 45 degrees F.

B. Humidity:40 to 90 percent.

C. Atmosphere: non-corrosive .

D. Ventilation: provided.

PART 2 PRODUCTS

2.01 GENERAL

A. Crane shall be as manufactured by one of the following:

1. Harrington Crane & Hoists.
2. Columbus McKinnon Corporation.
3. Demag Cranes.
4. Or approved equal.

B. Crane manufacturer to coordinate equipment requirements with steel structures, panels, drive motor, control panel, trolley and hoist, hoisting cable or chain, hook, crane mounted conductors, rails, stops, and electrical equipment controls.

C. Where adjustable speed drives or remote control systems are required, crane manufacturer to furnish a coordinated operating system.

2.02 RUNWAY

A. Runway beams, brackets, and associated framework furnished by the Contractor under Section 05 50 00, Metal Fabrications, and as shown on the Drawings.

B. Runway rails shall conform to cross-sections and weights per yard as specified in CMAA No. 70 or No. 74. Furnish rails, rail attachments, and conductors by crane manufacturer.

C. Contractor and crane supplier to coordinate runway travel stop locations with project specific crane travel requirements. Runway stops to be field adjustable.

2.03 BRIDGE

A. Furnish girders from structural shapes proportioned to resist vertical, lateral, and torsional forces.

B. Construct bridge end trucks in accordance with CMAA No. 70 or No. 74. Furnish end trucks with rail sweeps and impact-absorbing bumpers.

C. Furnish runway stops attached to resist force applied when contacted and locate at limit of travel of bridge. Runway stops shall not engage the wheels.

D. Provide bridge travel limit switches, located approximately 10 feet to 15 feet from each end of bridge runway, or as required such that bridge travel speed is reduced to low speed prior to bridge engaging runway end-stops. Bridge drive speed past the limit switch locations shall be limited to low speed.

E. Wheels: Rolled or forged steel with treads and flanges heat treated, or cast iron wheels with chilled tread. Minimum tread hardness 200 Brinell. Clearances, wheel loads, and tolerances in accordance with CMAA No. 70 or No. 74. For top-running cranes provide rotating axles and wheels mounted by press fit and keys.

F. Bridge driving machinery consisting of a single electrical motor through a gear speed reducer unit on each end truck.

G. Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

H. Bearings: Combination radial and thrust type, double row, spherical ball, either prelubricated and sealed or fitted for pressure lubrication. Pressure lubrication fittings for maintenance accessibility.

I. Brakes: Electrically operated, adjustable, suitable for the service class indicated, with rated torque capacities as specified in CMAA No. 70 or CMAA No. 74.

2.04 TROLLEY

A. Frame: Welded steel, cast steel, or ductile iron construction, or a combination thereof. Design to control deflection of trolley assembly while transmitting the carrying load to bridge rails.

B. Drive shall consist of trolley drive shaft, driven by an electric motor through a gear reduction unit.

C. Furnish roller assembly stabilizers on single-girder trolley units to prevent tipping during load pickup.

D. Wheels: Rolled or forged steel, accurately machined and ground to receive inner bearing races. Furnish alloy steel axles. Rotating axles with wheels mounted press fit and keys, or with keys alone. Minimum tread hardness 210 Brinell.

E. Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

F. Bearings: Combination radial and thrust type, double row, angular contact ball bearings or single-row tapered roller bearings. Bearings prelubricated and sealed, or fitted for pressure lubrication. Locate pressure lubrication fittings for accessibility during maintenance.

G. Brakes: Suitable for service class and rated torque capacities as specified in ASME B30.11. Furnish stops on trolley rails or beams.

H. For bridge spans greater than 40 feet provide trolley travel limit switches, located approximately 6 feet to 8 feet from each end of trolley rails/beams, or as required such that trolley travel speed is reduced to low speed prior to trolley engaging the trolley end-stops. Trolley drive speed past the limit switch locations shall be limited to low speed.

2.05 HOIST

A. Hoisting Machinery: Load chain wheel driven through gear reductions, an electric motor, load blocks, sheaves, chain, hook, and hoist braking.

B. Chain: Nonjamming close-link coil type. Chain hoists shall have chain storage adequate for storing the full lift length of chain and shall be designed and located to avoid interference while hoisting.

C. Hook: Construct with sufficient ductility to open noticeably before hook failure, equipped with safety latch, free to rotate 360 degrees with rated load, and positively held in place with locknuts, collars or other devices.

D. Brakes: In accordance with ASME HST 1M and HST 2M, adjustable to compensate for wear, positive action, Weston type mechanical load brake, with uniform composition lining and forged steel alloy latch pawl.

2.06 ELECTRICAL

A. Furnish electrical equipment including motors, motor starters, pendant control, control systems, wire, and conduit. Bridge conductors may be removed for shipment. Crane wiring by crane supplier.

B. Electrical: In accordance with NFPA 70, NEC Article 610.

C. Furnish motors compatible with adjustable frequency, variable speed, drive system, 40 to 1 speed range, suitable for hoist, trolley, and bridge drive applications. Controls with 120-volt ac, microprocessor based, pulsed width modulation design, withstand 45 degree C temperatures, housed in NEMA 250, Type 4 enclosure, and supplied with 200 percent over current protection.

D. Bridge and trolley conductor voltage drops from runway supply taps shall permit the crane motors to operate within voltage tolerances of plus or minus 10 percent, when building supply voltage is at plus or minus 5 percent of design voltage.

E. Festooned Flat Cable Conductors: Flexible cable, carried by heavy-duty roller, permanently lubricated roller bearings, with monorail support system that will dispense and retrieve flexible cable without twisting or tangling, and 20 percent spare conductor in each cable assembly.

F. Cable Reel Conductors: Flexible cable, housed on a circular wheel, counter-torque spring to dispense and retrieve cable, with sag not more than 3 feet below connection point on crane at maximum travel.

G. Grounding: External in accordance with NFPA 70, NEC Article 250.

2.07 CONTROLS

A. Furnish electric cranes with pendant control having momentary contact pushbuttons with a device which will disconnect motors from line on failure of power. Device shall not permit any motor to be restarted until controller handle is brought to the OFF position, or a reset switch or button is operated. Furnish with under voltage protection as a function of each motor controller, or by magnetic main line contactor.

B. Controls: Fully magnetic, plain reversing type, housed in NEMA 250, Type 12 enclosure, with contactors of sufficient size and quantity for starting, accelerating, reversing, and stopping duty for specified crane service class.

C. Bridge and Trolley Drives: Soft start controls, 460/230-volt ac series device, installed in between drive motor and motor starter with torque and acceleration rate adjustable, suitable for crane service, and work in conjunction with crane controls.

D. Pushbutton Control Stations: Heavy-duty, oiltight, suspended from trolley, with control transformers to supply 120-volt ac power to pushbutton control station. Pushbutton enclosure supported with chain or wire rope. Control wire cable attached to support chain or wire rope at not more than 6-foot intervals. Furnish control station buttons for control of bridge, trolley, and hoist, ON/OFF main line contactor power switch which removes all power from crane and controls.

2.08 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location. Mounted on separate components of each crane assembly, to facilitate assembly in the field.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Platform Truck: Provide one platform truck for each bridge crane. Minimum 3,600 pound capacity, with two fixed wheels and two swivel wheels and removable handle. Minimum deck size 36" x 72". Little Giant Model NB-3672-8PUBK, or equal.

2.09 FACTORY FINISHING

A. Prepare and prime coat in accordance with manufacturer's standard.

2.10 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels and equipment for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: No-load run test furnished.

C. Factory test report shall include Test Data Sheets.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Provide lubrication and lubrication fittings.

3.02 FIELD FINISHING

A. Touch-up painting for equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each crane.

1. Alignment: Test complete assemblies for proper alignment and connection, and quiet operation.

B. Performance Test:

1. Conduct on each crane.
2. Load tests in compliance with OSHA, ASME B30.11, and ASME B30.16.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. One person-day for installation assistance and inspection, for each crane.
2. One person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation for each crane.
3. One-half person-day for prestartup classroom or Site training.
4. One-half person-day for facility startup.
5. One-half person-days for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Owner.

3.05 CRANE DATA AND DIMENSIONS

A. The crane data and dimension information shown in the attachment is a part of this Specification.

END OF SECTION

Table 1		
Crane Data and Dimensions		
Treatment Plant	**FTTP**	
Individual crane unit	GAC PS Crane	UV Crane
General		
equipment capacity method of control	5 tons pendant	2 tons pendant
location of control	on trolley	on trolley
factory testing	required	required
field testing	required	required
power supply voltage	460	460
power supply phase	3	3
power supply frequency	60	60
indoor or outdoor	indoor	indoor
corrosive environment?	no	no
Bridge		
type service class	single girder, top running B (light)	single girder, top running B (light)
drive system	individual elec motors on end trucks	individual elec motors on end trucks
speed	40 fpm	40 fpm
nominal span(1)	20 feet	36 feet
Trolley		
type	underhung	underhung
service class	B (light)	B (light)
drive	elec motor	elec motor
speed	40 fpm	40 fpm
Hoist		
type	Electric wire rope	Electric wire rope
service class	H2 (light)	H2 (light)
speed low hook to high hook dimension	14 fpm 40 feet	14 fpm 30 feet
Notes		
(1) Manufacturer and Contractor to determine actual exact span required from construction drawings.		

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SECTION 41 22 23.19
MONORAIL HOISTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): MH27.1, Underhung Cranes and Monorail Systems.
2. American Society of Mechanical Engineers (ASME):
   a. B30.10, Hooks.
   b. B30.11, Monorails and Underhung Cranes.
   c. HST 1M, Performance Standard for Electric Chain Hoists.
   d. HST 2M, Performance Standard for Hand Chain Manually Operated Chain Hoists.
   e. HST 4M, Performance Standard for Overhead Electric Wire Rope Hoists.
3. National Electrical Manufacturer's Association (NEMA):
   a. MG 1, Motors and Generators.
   b. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Occupational Safety and Health Act (OSHA).
6. Underwriters Laboratory (UL): 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.02 DESIGN REQUIREMENTS

A. Monorail System: Specifications for Underhung Cranes and Monorail Systems, ANSI MH27.1 and ASME B30.11.

B. Hoist: ASME B30.11, Hoist Manufacturers' Institute.

C. Trolley: ANSI MH27.1.

D. Wire Rope Hoist Service Class: ASME HST 4M.

E. Chain Hoist Service Class: ASME HST 1M.

F. Hook: ASME 30.10.

G. Stress and Safety Factors: ANSI MH27.1 and ASME B30.11. Properly select materials of construction for stresses to which subjected.

H. Safety of Operation, Accessibility, Interchangeability, and Durability of Parts: ASME B30.11 and OSHA requirements.

I. Provide system, equipment, and components, including supports and anchorages, designed in accordance with Section 01 61 00, Common Product Requirements

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, lifting capacity and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, materials of construction, and specifications on hoist, wheels, gears and bearing, trolley drive system, hoist motor and assemblies, hook, brakes, starting system, variable speed drive system, conductors (bus bar, festoon, cable reel), controls, remote control system, and accessories.
   c. Power and control wiring diagrams, including terminals and numbers.
   d. Motor nameplate data in accordance with NEMA MG 1, and include any motor modifications.
   e. Factory finish system.

B. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer's printed installation instructions.
3. Factory Functional Test Report.
4. Suggested spare parts list to maintain the equipment in service for a period of 3 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Maximum 95 degrees F; minimum 50 degrees F.

B. Humidity: 40 to 90 percent.

C. Atmosphere: Non-corrosive.

D. Ventilation: Provided.

PART 2 PRODUCTS

2.01 GENERAL

A. Hoist equipment shall be manufactured and supplied to:

1. Harrington Crane & Hoists.
2. Columbus McKinnon Corporation.
3. Demag Cranes.
4. Or approved equal.

B. Hoist and trolley manufacturer to coordinate equipment requirements with steel structures, drive motor, hoisting cable or chain, hook, track, stops, and electrical equipment controls.

C. Where adjustable speed drives or remote control systems are required, crane manufacturer to furnish a coordinated operating system.

D. Furnish impact-absorbing bumpers.

2.02 TRACK

A. Track (monorail beam) shall be designed and specified by structural engineer of record.

2.03 TROLLEY

A. Frame: Welded steel, cast steel, or ductile iron construction, or a combination thereof. Construct to control deflection of trolley assembly while transmitting the carrying load to running surface.

B. Drive shall consist of trolley drive shaft, driven by an electric motor through a gear reduction unit.

C. Furnish roller assembly stabilizers on single-girder trolley units to prevent tipping during load pickup.

D. Wheels: Rolled or forged steel, accurately machined and ground to receive inner bearing races. Minimum tread hardness 210 Brinell.

E. Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

F. Bearings: Combination radial and thrust type, double row, angular contact ball bearings or single-row tapered roller bearings. Bearings prelubricated and sealed, or fitted for pressure lubrication. Locate pressure lubrication fittings for accessibility during maintenance.

G. Brakes: Suitable for service class and rated torque capacities as specified in ASME B30.11.

2.04 HOIST

A. Hoisting Machinery: Load chain wheel driven through gear reductions, an electric motor, load blocks, sheaves, chain, hook, and hoist braking.

B. Chain: Nonjamming close-link coil type. Chain hoists shall have chain storage adequate for storing full lift length of chain and shall be designed and located to avoid interference while hoisting.

C. Hook: Construct with sufficient ductility to open noticeably before hook failure, equipped with safety latch, free to rotate 360 degrees with rated load, and positively held in place with locknuts, collars or other devices.

D. Brakes: In accordance with ASME HST 1M and ASME HST 2M, adjustable to compensate for wear, spring set, electric release load brake system, which releases load when drive motor is energized and holds load when the drive motor is de-energized.

2.05 ELECTRICAL

A. Furnish electrical equipment including motors, motor starters, pendant control, control systems, wire, and conduit.

B. Electrical: In accordance with NFPA 70, NEC Article 610.

C. Furnish motors compatible with adjustable frequency, variable speed, drive system, 40 to 1 speed range, suitable for hoist, trolley, and bridge drive applications. Controls with 120V ac, microprocessor based, pulsed width modulation design, withstand 45 degree C temperatures, housed in NEMA 250, Type 4 enclosure, and supplied with 200 percent overcurrent protection.

D. Monorail conductor voltage drops from monorail track supply taps shall permit the hoist and trolley motors to operate within voltage tolerances of plus or minus 10 percent, when building supply voltage is at plus or minus 5 percent of design voltage.

E. Festooned Flat Cable Conductors: Flexible cable, carried by heavy-duty roller, permanently lubricated roller bearings, with monorail support system that will dispense and retrieve flexible cable without twisting or tangling, and 20 percent spare conductor in each cable assembly.

F. Cable Reel Conductors: Flexible cable, housed on a circular wheel, counter-torque spring to dispense and retrieve cable, with sag not more than 3 feet below connection point on hoist or trolley at maximum travel.

G. Grounding: External in accordance with NFPA 70, NEC Article 250.

2.06 CONTROLS

A. Hoist and Trolley: Pendant control having Momentary contact pushbuttons with a device which will disconnect motors from line on failure of power. Device shall not permit any motor to be restarted until controller handle is brought to the OFF position, or a reset switch or button is operated. Furnish with undervoltage protection as a function of each motor controller, or by magnetic main line contactor.

B. Pushbuttons: Fully magnetic, plain reversing type, housed in NEMA 250, Type 12 enclosure, with contactors of sufficient size and quantity for starting, accelerating, reversing, and stopping duty for specified hoist service class.

C. Trolley Drives: Soft start controls, 460/230V ac series device, installed between drive motor and motor starter with torque and acceleration rate adjustable, suitable for trolley drive service, and work in conjunction with pendant system.

D. Pendant Pushbutton Control Stations: Heavy-duty, oiltight, suspended from hoist, with control transformers to supply 120V ac power to pushbutton control station. Pushbutton enclosure supported with chain or wire rope. Control wire cable attached to support chain or wire rope at not more than 6-foot intervals. Furnish control station buttons for control of hoist ON/OFF main line contactor power switch which removes all power from control station.

2.07 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

2.08 FACTORY FINISHING

A. Prepare and coat in accordance with manufacturer's standard.

2.09 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels and equipment for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: No-load run test all equipment furnished.

C. Factory test report shall include Test Data Sheets.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Provide lubrication and lubrication fittings.

3.02 FIELD FINISHING

A. Equipment touch up painting as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each hoist and monorail system.

1. Alignment: Test complete assemblies for proper alignment and connection, and quiet operation.

B. Performance Test:

1. Conduct on each hoist and monorail system.
2. Load tests in compliance with OSHA, ASME B30.11, and ANSI MH27.1

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1/2 person-days for installation assistance and inspection.
2. 1/2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. Zero person-days for prestartup classroom or Site training.
4. 1/2 person-days for facility startup.
5. 1/2 person-days for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Owner [

3.05 HOIST DATA

A. The hoist/monorail data sheet attached is a part of this Specification.

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HOIST/MONORAIL DATA SHEET System No. 1

Project: Fort Thomas WTP

Owner: Northern Kentucky Water District (NKWD)

Service: Pump Removal--EQ Pump Station

Equip. Tag Number(s):

GENERAL REQUIREMENTS

Equipment Capacity: 2 tons	Factory Testing:	
Method of Control: Pendant	☒Required ☐Not Required	Voltage 460 V
Location of Control:	Field Testing: ☒Not required	Phase 3
Equipment Location:	☐Required, functional and performance	Frequency 60 Hz
☒Indoors ☐Outdoors		

HOIST	TROLLEY
Type:	Type:
☒Electric, Chain ☐Hand Operated, Chain	☐Top Running ☒Underhung
Service Class (ANSI):	Service Class (ANSI):
☐H1 (standby) ☒H2 (light) ☐H3 (standard)	☐A1 (standby) ☐A2 (infrequent) ☒B (light)
☐H4 (heavy) ☐H5 (severe)	☐C (moderate) ☐D (heavy)
Speed (fpm): 14 to	Speed (fpm): 40 to
☒Constant Speed ☐Two Speed ☐Variable Speed	☒Constant Speed ☐Variable Speed ☐Hand Operated
Motor hp: 2.4	Motor hp: 0.54
	Electric Conductors:
	☐Bus Bar ☐Festoon ☐
	☐Cable Reel

SPECIAL REQUIREMENTS

Accessories:	Remote Controls:	Special Electrical Requirements:
☐Central Lubrication System	☐Infrared, line-of-sight	
☐OSHA operating and safety devices	☐Frequency modulated (FM)	
	Manufacturer:	
	☐Extended Grease Fittings	

See Hoist/Monorail Dimension Sheet for clearances, lift distances, and details.

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SECTION 43 31 13.13
GRANULAR ACTIVATED CARBON (GAC) FILTER MEDIA

PART 1 GENERAL

1.01 SUMMARY

A. This Work includes providing granular activated carbon (GAC) products for use as a media in Northern Kentucky Water District's Fort Thomas Treatment Plant (FTTP) contactors. The GAC shall be capable of removing organic carbon, color, tastes, odors and other organic contaminants from effluent from water pretreatment processes. The GAC shall be made from selected grades of North American based virgin bituminous coal, capable of withstanding repeated backwash procedures without significant change in physical sizes, and shall be suitable for thermal reactivation and re-use. Only bituminous coal-based re-agglomerated GAC will be acceptable.

1. Contactors at FTTP: Eight (8) contactors consisting of 144 inches of GAC media. Each contactor is composed of one cell with approximate dimensions of 22 feet by 40 feet, for 880 square feet per contactor.

B. Unit Responsibility: The Work requires that the GAC media be the end product of one responsible system manufacturer or supplier. Unless otherwise indicated, the Contractor shall obtain each system from the responsible supplier of the equipment. The supplier shall furnish and/ or coordinate all components and accessories as necessary to place GAC media in operation in conformance with the specified performance, features, and functions indicated without altering or modifying the Contractor's responsibilities under the Contract Documents. The Contractor is responsible to the Owner for providing the equipment systems as specified herein.

C. General Requirements: See Division I, General Requirements, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. B100, Granular Filter Material.
   b. B604, Granular Activated Carbon (GAC).

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Submit manufacturer's product information not less than 30 days prior to shipment, including grain size ranges for the GAC media specified, specific gravity, in place density, total ash percent, molasses, and iodine number. Media sizes shall be in millimeters and include Effective Size (ES) and Uniformity Coefficient (UC). Data on flow rate versus expansion of the media during fluidization backwashing at three different temperatures (5, 15, and 25 °C) shall also be included. This data shall be expressed as a percentage of in-service bed depth versus backwash flow rate (gpm per square foot of contactor surface area). Clean bed head loss data at each temperature shall be included.
2. Contractor shall provide details of the proposed method for installation of the new GAC in the filters. Include descriptions of equipment to be used, and provide photographs for clarity. The methods and equipment shall be approved, in writing, by the Manufacturer.
3. Samples: Submit no less than 2-pound samples of GAC media following delivery of shipment, with a Certificate of Analysis which shall certify that sample shipped to the Site is from the same batch as that shipped to the Project Site, virgin carbon and in full compliance with the specifications noted in Article 2.02.
4. Verification of NSF 61 certification shall be provided
5. Resumes for On-site Technical Representative and Installation Supervisor.

B. Informational Submittals:

1. Submit gradation test results of GAC media, including sieve analysis prior to loading and shipment.
2. Submit data showing successful application of the GAC in municipal water treatment plants including organic contaminant removal, along with references.
3. Manufacturer's Certificate of Proper Installation
4. Operations and Maintenance Data: As specified in Section 01 33 00, Submittal Procedures.

PART 2 PRODUCTS

2.01 MANUFACTURERS OF GRANULAR ACTIVATED CARBON

A. Calgon Carbon Corporation.

B. Norit Americas, Inc.

C. Or approved equal.

D. The manufacturer shall have a minimum of 10 years experience in supplying GAC to water treatment plants.

2.02 SPECIFICATIONS

A. The GAC shall be clean, hard, durable particles in conformance with AWWA B604, modified as follows:

1. Deliver GAC in semi-bulk, bulk containers or bulk trailer.
2. The GAC shall be NSF Standard 61 certified virgin material manufactured from select grades of bituminous coal having the following properties:
   a. Particle Size Distribution: 12 by 40 carbon with maximum of 5 percent by weight larger than No. 12 mesh (1.68 mm) sieve and maximum of 4 percent by weight smaller than No. 40 mesh (0.42 mm) sieve.
   b. Granular activated carbon with effective size of 0.55 to 0.75 mm, Uniformity Coefficient of no greater than 1.9.
   c. Minimum abrasion number of 75 (75 percent as determined by either the stirring abrasion test or the Ro-Tap abrasion test).
   d. Minimum adsorptive capacity as measured by iodine number of 1000 mg iodine/g carbon.
   e. Maximum water soluble ash of 0.5 percent by weight.
   f. Maximum total ash content of 9 percent by weight.
   g. Maximum moisture as packed of 2.0 percent by weight.
   h. Apparent density, backwashed and drained of 0.46 to 0.65 g/cm^3.
   i. Particle density, wetted in water of 1.3 to 1.4 g/cm^3.
   j. Pore volume of 0.75 to 0.85 cm^3/g.
3. Depth: 144 inches. See Drawings for contactor dimensions. Depth shall be measured following backwashing and fines removal as described below.
4. The GAC shall be manufactured in the United States of America.
5. All GAC shall be thermally activated by re-agglomeration.
6. All GAC shall be virgin. GAC shall be an agglomerated bituminous coal-based product with petroleum and coal based pitch binders sized to a granular form prior to baking and activation. Broken pellets will not be accepted. Lignite, peat, wood, coconut, direct activated, recycled, or used GAC will not be accepted.
7. Manufacturer shall indicate the source of the coal, carbon manufacturing location, the agglomeration/thermal process and capacity of the manufacturing facility.
8. The Owner's Representative reserves the right to inspect the GAC manufacturing and thermal processing facility.

2.03 SOURCE QUALITY CONTROL

A. Samplings

1. Sampling shall be in accordance with AWWA B604.
2. The media manufacturer shall perform analyses to confirm gradation, effective size, uniformity coefficient, iodine number, total ash content, and specific gravity on the media prior to shipment.

B. Testing:

1. The pre- shipment media testing shall be performed by an independent test laboratory retained by the GAC media supplier.
2. Sieve analyses shall be performed in accordance with AWWA B100. Test reports shall include raw data, graphical results, computation of effective size, and uniformity coefficient.
3. The specific gravity shall be determined for each sample. Testing shall be in accordance with AWWA B 100.
4. Media supplier shall provide affidavit of compliance.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. GAC depletes oxygen from air and can be hazardous in a confined situation. Contractor shall be responsible for worker's safety and follow all local, State, and Federal guidelines pertaining to confined space entry procedures. Obtain necessary permits for work in confined areas.
2. The GAC shall be installed as a wet slurry to minimize abrasion and dust as specified in AWWA B604. Installation of dry media shall not be allowed.
3. Do not permit workers to walk or stand directly on media. Use boards that will sustain workers' weight without displacing media or support sand if specified. All equipment used in placing the GAC in the contactor shall be cleaned and disinfected in accordance with AWWA C653. All workers shall wear boots and gloves which has been disinfected in accordance with AWWA C653.
4. Before GAC media is placed, mark top of GAC layer on side of filter.
5. Owner is responsible for operating the contactor controls during the backwash operations.

B. Services By the Owner

1. The Owner will provide a potable water supply capable of supplying approximately 110 gallons per minute of water at approximately 100 psig at the point of connection. If the Contractor's operations require additional flow or pressure, the additional facilities shall be provided by the Contractor.
2. Excess water from the GAC placement shall be drained to the EQ Basin using facilities installed as a part of this project. The Contractor shall contain any excess water and route it to the facilities provided. Contractor shall take all means necessary to avoid GAC spillage on the parking lots, drives, and inside of the building.

C. GAC Media:

1. Transport and place media carefully to prevent contamination of any sort.
2. Any filter media which becomes contaminated or dirty (i.e., contains more than 0.5 percent of foreign material by weight), either before or after it has been placed in the filters, shall be removed and replaced with clean media at no cost to the Owner.
3. Install in following sequence:
   a. The contactors shall be partially filled with water prior to placing the GAC media.
   b. The GAC media shall be placed in a minimum of three (3) lifts not exceeding four (4) feet in depth (after permanent expansion) each.
   c. The GAC media shall be placed using a slurry and backwashing may begin four (4) hours after completion of GAC lift placement.
   d. After wetting the media, the bed shall be backwashed with water at a reduced rate (less than or equal to 5 gpm/sf) to remove carbon fines and level the media. Air backwash, at a reduced rate as recommended by the media manufacturer, shall be used to facilitate fines removal. As the fines are removed and the media is clearly visible, the backwash rate shall be increased to a provide 30% expansion of the total bed depth. The rate shall be adjusted based upon water temperature and GAC characteristics. This rate shall be maintained for a minimum of approximately 10 minutes, and then reduce backwash rate to 5 gpm/sf and hold for at least 30 seconds and then slowly close the backwash valve. The backwash procedure shall be repeated a minimum of two more times. Scrap fines after each backwash. The Owner will operate the backwash facilities with advanced notification and as needed to maintain plant operations. Backwashing may occur over a 36-hour period

to avoid overfilling the backwash waste equalization basin and unacceptable water levels in the system. Contractor shall provide assistance as required.

e. Add GAC media for subsequent lifts and repeat the backwash procedure outlined above.

f. Add GAC media to the full GAC volume to achieve the full depth of media as shown and specified and including considerations for loss of fines and permanent expansion of the GAC. Repeat the backwash procedure outlined above.

g. After placement of the last GAC media, perform a total of three backwashes according to the backwash procedures for the final facility.

4. Final depth of GAC media after washing shall be the specified depth of 144 inches plus or minus 2- inches at Fort Thomas Treatment Plant. If the final media depth is below this minimum, Contractor shall install additional GAC and complete backwashing as required to reach the specified depth at their own expense. If the final media depth is above this maximum, Contractor may be required to remove additional GAC if directed by the Owner's Representative.

3.02 FIELD QUALITY CONTROL

A. Pre-Installation:

1. Sampling shall be in accordance with AWWA B604.
2. After media is delivered, Contractor shall employ an independent testing company to collect representative samples of media for testing and Owner samples.
3. Samples shall be collected in a core sampler. The representative samples from the bulk container or bag shall be combined to produce the required composite sample.
4. Samples shall be collected for each media for testing. Each sample shall consist of sufficient media as required per AWWA B604.
    a. Minimum number of sacks for sampling: 40 super sacks.
    b. Minimum of one (1) sample per truck for bulk containers.
5. Testing shall be completed in accordance with AWWA B604.

3.03 DISINFECTION

A. Prior to installation of GAC media, the sand support media and the contactor box shall be disinfected. See Section 33 13 00, Disinfecting of Water Utility Distribution, 44 43 30 Filter Media, and 44 33 34 Filter Underdrain System.

3.04 MANUFACTURER'S SERVICES

A. A manufacturer's On-site Technical Representative for the GAC media specified shall be present at the Job Site for a minimum of one (1) day during placement of media in the first contactor for installation training, supervision, inspection, and certification of the installation. The representative shall be a full-time, direct employee of the filter media supplier and shall have a minimum of 2 years experience during the past 5 years in GAC contactor media installation.

B. In addition, a manufacturer's Installation Supervisor shall be onsite to observe and supervise the installation of all of the GAC media in all of the contactors.

C. Provide a manufacturer's certificate of proper installation in accordance with Division 1, General Requirements.

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SECTION 44 42 19.04
ROTARY POSITIVE DISPLACEMENT BLOWER

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gear Manufacturers Association (AGMA).
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
4. National Electrical Manufacturers Association (NEMA).

1.02 DEFINITIONS

A. Absolute Discharge Pressure: Pressure in pounds per square inch absolute (psia) at the blower discharge flange in relation to Job Site barometric pressure.

B. BHP: (Shaft) brake horsepower is the standard curve horsepower required corrected for pressure, temperature and relative humidity at inlet conditions.

C. Discharge Pressure: Pressure in pounds per square inch gauge (psig) at the blower discharge flange at rated capacity.

D. Inlet Cubic Feed per Minute (ICFM): Volumetric rate of air at the inlet flange of the blower corrected to absolute pressure, temperature, and relative humidity. The pressure takes into account the inlet piping in filter pressure drops.

E. Pressure Rise: Pressure developed within the blower between the inlet and outlet flanges. It is the discharge pressure less the inlet pressure measured at the discharge and inlet flanges, respectively.

F. Standard Cubic Feet per Minute (SCFM): Volumetric rate of air measured in standard cubic feet per minute at 68 degrees F, pressure of 14.2 psig, and relative humidity of 36 percent.

1.03 SYSTEM DESCRIPTION

A. Blower system, featuring rotary positive displacement blower(s) to supply air for the GAC Contactor backwash process system.

B. Provide blower system, including, but not limited to, blowers, , motors, drives, guards, baseplates, vibration isolators, supports, inlet silencers, discharge silencers, bypass silencers, relief valves, check valves, butterfly valves, flexible connectors, noise enclosures, spare parts, and miscellaneous appurtenances as necessary.

1.04 DESIGN REQUIREMENTS

A. Design equipment with due regard to safety of operation, accessibility, and durability of parts, and complying with applicable OSHA, state, and local safety regulations.

B. The blower will receive outside air and discharge into a main air discharge header.

C. Intermittent operation in an indoor environment.

D. Blower(s) shall start no more than four times per hour when operating in intermittent service.

E. Maximum Sound Pressure Level: 80 dBA, factory calculated, with inlet and discharge silencers, measured with a sound enclosure.

F. Performance Requirements:

Design Conditions	
Design Capacity, scfm	1760
Design Capacity, icfm	2000
Altitude, ft	790
Barometric pressure, psia	14.3
Inlet air temperature, degrees F (Maximum)	100
Relative humidity, %	85
Blower pressure rise required, psi	12
Pressure relief valve setting, psig	13

Design Conditions	
Shaft brake horsepower, BHP[1,2] (Maximum)	**156.1**
[1]Includes main oil pump, if specified, and all gear and bearing frictional losses. [2]Not to exceed motor nameplate horsepower at 1.15 service factor at the inlet air temperatures, pressure relief valve setting and altitude listed above.	

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete list of system components to be provided.
   b. Make, model, weight, and horsepower of each equipment assembly.
   c. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   d. Standard and specialized equipment assembly cuts.
   e. System layout, installation, and placing drawings for equipment, drivers, and bases.
   f. Performance data for each type of equipment that will show compliance with specification requirements stated herein.
   g. Horsepower demand over the operating range of the blower.
   h. Factory calculated sound levels (dBA) of blower unit and silencers.
   i. Factory calculated sound levels (dBA) of blower unit with silencers and sound enclosure.
   j. Detailed structural, mechanical, and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work.
   k. Motor: See requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
   l. Sound Enclosure:
      1) Complete description of sound enclosure and accessories.
      2) Calculated noise attenuation.
2. Samples: Color samples for finish coating. If paint manufacturer of finish coat differs from manufacturer of prime coat, provide both manufacturers' written confirmation that materials are compatible.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Identification of outside utility requirements for each component such as air, water, power, etc. Include operating parameters for required utilities.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's written installation instructions.
5. List of special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. Routine maintenance requirements prior to plant startup.
8. Test Reports:
   a. Factory test reports for blower and motor.
   b. Field test procedures.
9. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
10. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Oil, synthetic	10 gallons for 4000 -hour oil change interval
Inlet Filters	Enough for 4 complete changes per unit
Flexible Coupling	One complete set
V-Belts	One complete set
Special tools required to maintain or dismantle	One complete set

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

A. General:

1. Where possible, provide end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, replacement, and manufacturer's service.
2. Manufacture spare parts to United States standard sizes and gauges.

B. Materials, equipment, and accessories specified in this section shall be products of:

1. Aerzen: GM60S Generation Five.
2. Gardner Denver: Attenu-Pac, Duroflow Model 7018.
3. Kaeser: Com-Pak HB950C.
4. Roots: EasyAir X2.
5. United Blower: Robox RB5-1155.
6. Or approved equal.

2.02 COMPONENTS

A. Blower:

1. Rotary positive displacement type, V-belt driven by horizontal electric motor.
2. Casing: One-piece construction, ASTM A48/A48M, Class 30B close-grain cast iron strongly ribbed to prevent distortion at the specified operating conditions. Separate or integral headplates of cast iron.
3. Bearings:
   a. Each shaft and impeller assembly shall be supported by oversized anti-friction bearings engineered for long service life and fixed to control the axial location of the impeller/shaft in the unit.
   b. A cylindrical roller bearing shall be provided at the drive shaft designed to handle the stresses of the V-belt drive.
   c. Single-row ball bearings or cylindrical roller bearing shall be used at all other locations.
   d. Bearings and gears shall be lubricated by a splash type lubrication system on both ends of the rotors.
   e. Provide each bearing with a positive lip type oil seal designed to prevent lubricant from entering air stream and a labyrinth seal on each shaft designed to reduce air leakage at point where shaft extends through headplate of blower casing.
   f. Make further provision to vent area between the two sealing systems to atmosphere to relieve excessive pressure on seals.

4. Impellers:
    a. Each impeller shall be made from high-strength ASTM A395/A395M Type 60-45-15 ductile iron with a minimum tensile strength of 60,000 pounds per square inch.
    b. The impellers shall be flange attached to the steel shaft, or the impeller and shaft shall be a one-piece, ductile iron design.
    c. Straight, two-lobe or three-lobe involute type, rotating in opposite directions in a common casing without rubbing, liquid seals, or lubrication.
    d. The impellers shall be center timed or off-set timed by a pair of alloy steel spur gears to permit rotation in either direction.
    e. Impellers and timing gears shall be mounted on shafts supported by antifriction bearings, fixed to control the axial location of impeller/shaft in the casing.
    f. Statically and dynamically balanced by removing metal from impeller body.

B. Motor:

1. Squirrel-cage ac induction type, meeting requirements of Section 26 20 00, Low-Voltage AC Induction Motors, and as specified herein.
2. Motor Horsepower: 200.
3. Nominal Speed: 1,750 rpm, constant.
4. Rated Voltage: 460 volt, three-phase, 60-Hz.
5. Enclosure Type: TEFC, as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
6. Inverter duty rated.
7. Drive: Heavy-duty multiple V-belts. An automatic v-belt tension system shall be supplied.
8. Motor Efficiency: Premium efficiency as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
9. Service Factor: 1.15
10. Motor shall be equipped with a normally closed thermostatic heat protection device to protect the motor from overheating during operation. The unit shall immediately stop the motor in the event of excessive heat build-up.

C. Enclosure:

1. Each blower shall be furnished with an enclosure to attenuate noise. The enclosure shall provide a guaranteed noise level of 80 dBA or less at 1 meter from the enclosure free field.
2. The enclosure shall be steel and provided with a corrosion resistant coating.

3. The enclosure shall include a ventilation system and removable panels for easy access and maintenance. Each enclosure shall use ventilation fans, which shall operate off of 120 volt, 1 phase, 60 hertz power.
4. The noise enclosure shall be supplied by the blower manufacturer.
5. The blower and all accessory equipment, except for the flexible connector and the butterfly valve, shall be factory mounted inside of or integral to the enclosure. Enclosures shall include vibration isolators for the blower and equipment base.

2.03 ACCESSORIES

A. Each blower shall be provided with the following items:

1. Inlet Filter Silencer
2. Combination Base with Discharge Silencer
3. Pressure Relief Valve
4. Dual Plate Check Valve
5. Butterfly Valve
6. High Pressure Cut-Off Switch/Gauge
7. High Temperature Switch/Gauge
8. Flexible Connector
9. Inlet Filter Differential Pressure Gauge
10. Bypass Silencer
11. Lifting Lugs
12. Equipment Identification Plates
13. Anchor Bolts
14. Shop/Factory Finishing

B. Inlet Filter Silencer:

1. Dry element type with a washable filter media.
2. Sized to pass 100% of the blower flow with a pressure drop not to exceed 3 inches of water column (w.c.) For a clean filter.
3. The filter element shall be cleanable and replaceable.
4. The filter shall be equipped with a filter restriction indicator (filter differential pressure gauge) suitable for up to 20 inches of water column.
5. The gauge shall be pre-pipe and panel mounted on the enclosure.

C. Combination Base with Discharge Silencer:

1. Chamber type, horizontal arrangement, connected to the blower discharge.
2. The silencer shall be sized such that a pressure drop of 5.5 inches w.c. shall not be exceeded at the scheduled blower operating conditions.

D. Pressure Relief Valve:

1. Mounted on the exit chamber of the blower discharge silencer.
2. Spring-type relief valve having 10% maximum accumulation at the maximum blower operating capacity.
3. Bronze inserts and discs and rated for temperatures up to 400° F.
4. Valve shall be Kunkle Model 337 for pressure service, or approved equal.
5. The relief valve exhaust shall be piped out of the enclosure. Pipe shall be Type 316 stainless steel, Schedule 5, and shall have plain end discharge minimum 7'-0" A.F.F. and directed away from personnel access areas.
6. Manufacturers and Products:
   a. Mercer, Style 500.
   b. Red Valve, J-1.
   c. Proco, Series 230.
   d. Or approved equal.

E. Dual Plate Check Valves:

1. Location: Outlet of each blower.
2. Type: Wafer, split disc.
3. Size: Match blower discharge.
4. Cast iron or carbon steel body; Type 316 stainless steel plates, hinge, stop pin, pin retainer, and spring; Viton seals and seats.
5. Manufacturer: Cameron, "Techno" Dual Plate Check Valve ; or approved equal.

F. Butterfly Valves:

1. Location: As shown on Drawings, shipped loose.
2. Type: One piece casting with flanged ends (short body) meeting ANSI B16.1 standards.
3. Size: As shown on Drawings.
4. Body: Cast iron (ASTM A126, Class B).
5. Disc: Cast iron with Type 316 stainless steel edge. Disc-to-shaft connection shall be Type 316 stainless steel.
6. Shaft: Type 416 stainless steel. One piece through-shaft with self-locking stainless steel disc screws.
7. Bearings: PTFE coated stainless steel (permanently lubricated).
8. Seats: Viton (field replaceable).
9. Packing: Graphite Teflon braid.
10. Provide external indication of disc position.

G. High Pressure Cut-Off Switch/Gauge:

1. Panel mounted.
2. DPDT output.
3. Rated for 120 VAC NEMA 4 enclosure.
4. Pre-piped and factory mounted on the enclosure.

H. High Temperature Switch/Gauge:

1. Panel mounted.
2. SPDT output.
3. Rated for 120 VAC NEMA 4 enclosure.
4. Internal adjustment with reference dial and immersion stem.
5. Pre-piped and factory mounted on the enclosure.

I. Flexible Connectors:

1. Location: Outlet of each blower.
2. Type: Elastomeric, compatible with air service.
3. Size: Match blower discharge.
4. Tube and Cover: Synthetic or natural rubber.
5. Retaining Rings: Steel with hot dipped galvanizing in accordance with ASTM A123. Drilled to match flange drilling.
6. Flanges: Full, flat faced, ANSI Class 125 drilling.
7. Temperature and Pressure Rating: Suitable for positive displacement blower application.

J. Inlet Filter Differential Pressure Gauge:

1. Panel mounted.
2. Pre-piped and factory mounted on the enclosure.

K. Bypass Silencer:

1. Straight-through absorptive type.
2. Annular flow path with blocked line-of-sight.
3. Two concentric perforated cylinders lined with acoustical pack.
4. Inlet and outlet flanges shall match the piping size shown on Drawings. Flange drilling shall be ANSI Class 125. Mount as shown on Drawings.
5. Provide drain coupling and plug.
6. Manufacturer: Universal Series SU5, or approved equal.

L. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

M. Equipment Identification Plates: Provide 16-gauge Type 316stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification.

N. Anchor Bolts: Type 316 stainless steel adhesive anchors, sized by equipment manufacturer,1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.

O. Shop/Factory Finishing:

1. Surface preparation, prime and finish coatings shall be factory applied by the manufacturer and shall be in accordance with the requirements of Section 09 90 00.
2. Buy-out items, motors, reducers, etc., shall be furnished with manufacturer's factory-applied epoxy coating system (i.e., mill and chemical duty), which shall be compatible with Section 09 90 00.
3. Machined, polished and nonferrous surfaces shall be coated with corrosion prevention compound.
4. Galvanizing shall be as specified in Section 05 50 00, Metal Fabrications.

P. The blower shall be installed at the blower area shown on the Drawings and shall be powered and controlled as indicated in the Contract Documents. All additional costs resulting from accommodating equipment other than what is shown on the Drawings and specified herein, including all structural, mechanical, process, instrumentation, and electrical changes, and all costs for engineering changes to the Contract Documents and redesign, inclusive of all costs for record drawings and facility O&M manual preparation, shall be the responsibility of the CONTRACTOR.

2.04 INSTRUMENTATION AND CONTROLS

A. The blowers shall be operated manually or automatically by equipment described in Divisions 26 and 40. The pilot control circuits for these blowers are shown on the Drawings. Any additional materials or equipment required by the manufacturers of these blowers, but not shown on the Drawings, to allow these blowers to function in the required manner, shall be furnished and installed as part of the work of this Section. All electrical equipment furnished under this Section shall comply with the requirements of Division 26, Electrical.

B. SOURCE QUALITY CONTROL

1. Manufacturer's Requirements:
   a. Blower package manufacturer shall have in place a full capability service organization.
   b. Such service organization shall include at least one stocking distributor in Kentucky.
2. Blower Performance Test:
   a. Notify Engineer at least 21 days prior to performing test.
   b. Perform on the blower actually furnished in accordance with manufacturer's established criteria.
   c. Test blower for a minimum of 1 hour after stabilization at conditions near the performance ratings for mechanical integrity and flow performance.
      1) Perform at or above specified performance pressure rise.
      2) Tolerance on Flow: Plus or minus 4 percent, after correction to rated conditions.
   d. Measure power consumption using a calibrated wattmeter.
   e. Test Report: Confirm capacity and power, complete with data and calculations used in the test.
3. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

PART 3 EXECUTION

3.01 EXAMINATION AND VERIFICATION OF CONDITION

A. Assure that all materials delivered to the job site have been fabricated in accordance with the approved Shop Drawings and are free from obvious shipping damage or defects.

B. Examine locations to receive blower packages for proper anchor bolt locations and any unevenness, irregularities or incorrect dimensions.

C. Notify the OWNER immediately of all unsatisfactory or non-conforming conditions.

3.02 PREPARATION

A. Delivery and Handling of Equipment:

1. Inspect all equipment and materials against approved Shop Drawings at time of delivery.
2. Equipment or materials damaged or not meeting the requirements of the approved Shop Drawings shall be immediately returned for replacement or repaired.

3. Blower packages shall come completely assembled and protected on wooden skids.
4. Blower package discharge ports shall be protected against entry of foreign objects.
5. Storage:
    a. Carefully prepare for storage and label all equipment and materials after they have been inspected.
    b. Store all equipment and materials in a dry covered, ventilated location and protected from harm according to the Manufacturer's instructions.
    c. Cap all pipe connections.
    d. Blower packages shall remain on original skid until time of actual installation.

3.03 INSTALLATION

A. Installation shall be in complete accordance with approved Shop Drawings and Manufacturer's instructions and recommendations, as shown on the Drawings and as specified herein.

B. Piping shall be supported independent of blower packages.

C. Connect all piping, valves and accessories as detailed on the Drawings and approved Shop Drawings.

D. Installation shall include furnishing and applying lubricants as recommended by the manufacturer.

E. Complete all field electrical power and control connections as described in Part 1 of this Section as a part of Division 26.

F. Grease bearings as per manufacturer's recommendations prior to starting blowers.

G. Check for proper rotation.

H. Adjust vibration mountings to remove excessive vibration.

I. CONTRACTOR shall verify that structures, pipes and equipment are compatible.

J. Make adjustments required to place system in proper operating condition.

K. Leave blower packages in working order.

L. Field Painting:

1. Field touch-up painting shall be in accordance with the requirements of Section 09 90 00.
2. Apply finish touch-up coats following blower installation and adjustment but prior to blower start-up.

3.04 FIELD QUALITY CONTROL

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Manufacturer's Field Service Report: Manufacturer's representative shall perform field inspection of all components prior to placing in operation and submit Manufacturer's Installation Inspection Report addressing the following:

1. List of deficiencies found.
2. Recommended corrective action for all deficiencies.
3. Certification by Manufacturer's representative that items are properly installed and adjusted.

C. Manufacturer's representative shall revisit the jobsite as often as necessary until all trouble is corrected and to the satisfaction of the OWNER.

3.05 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 2 -person-day for installation assistance and inspection.
2. 1-person-day for functional testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1-person-day for post-startup training of Owner's personnel.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 44 42 28
WEIR AND BAFFLE PLATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): F102, Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets.
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   c. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   d. A276, Standard Specification for Stainless Steel Bars and Shapes.
   e. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   f. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
   g. C581, Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.
   h. C920, Standard Specification for Elastomeric Joint Sealants.
   i. D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
   j. D570, Standard Test Method for Water Absorption of Plastics.
   k. D638, Standard Test Method for Tensile Properties of Plastics.
   l. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   m. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed description of laminate and type of reinforcing to be used.
   b. Manufacturer's drawings showing dimensions of the items and accessories being provided.
   c. Complete information regarding the specific resin to be used.
2. Sample: not required.

B. Informational Submittals:

   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 33 00, Submittal Procedures, and stating the following:
      1) Reinforcing material used will provide suitable chemical resistance.
      2) Resin is suitable for the environmental conditions intended and the fabrication technique proposed.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Site properly packaged for ease of handling and to minimize damage during shipping.

B. Handling and storage of the items provided hereunder shall be in strict accordance with the manufacturer's printed instructions. Care shall be taken not to damage the components and accessories.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of equipment specified herein shall be the end products of one manufacturer in order to achieve standardization of appearance, operation, maintenance, and manufacturers' services.

2.02 MATERIALS

A. Fiberglass:

1. Match-die molded fiberglass, 1/4-inch minimum thickness, in accordance with AWWA F102.
2. Resin: Except as modified by this Specification, conform to ASTM C581:

a. Type II: Suitable for intended service; premium grade and corrosion-resistant such as chlorendic polyester, vinyl ester, or bisphenol A fumarate polyester.
b. Shall not contain fillers or thixotropic agents, except as may be required, and shall conform to resin manufacturer's recommendations.
    1) Glass Content: 20 percent to 30 percent.
    2) Inorganic Fillers: No less than 40 percent of resin mixture.
c. Coloring: Pigmented gel-coat containing ultra-violet blocking agent; manufacturer's standard color.
d. Sufficient thixotropic agents to form a paste to seal machined or cut edges.
e. Reinforcement:
    1) Commercial grade glass, made specifically for use in fiberglass reinforced plastic, and having a coupling agent providing a compatible bond between the glass reinforcement and the resin.
    2) Weight and density may be varied to obtain necessary resin-glass ratio and structural strength for the specified service.
f. Mold Surfaces: Reinforced with surfacing mat, followed by minimum of 3 ounces of chopped strand mat, in a minimum of two layers, with no other product introduced between layers.
g. Exposed Surfaces:
    1) Resin-rich, 10 mils to 20-mils thick with Type C surfacing mat, silane finish, and styrene-soluble binder.
    2) Glass fibers shall not be exposed.
    3) Chopped strand and chopped strand mat shall be Type E glass with silane finish and styrene-soluble binder.
    4) Minimum Glass Content: 30 percent by weight.
h. Laminates:

Property (70 Degrees F)	ASTM Standard	Value
Ultimate Tensile Strength, psi	D638	7,500 minimum
Flexural Strength, psi	D790	16,000 minimum
Flexural Modulus, psi	D790	800,000 minimum
Water Absorption	D570	0.2% in 24 hours
Impact, foot-pounds	D256	10

i. Barcoal Hardness: ASTM D2538; minimum 90 percent of resin manufacturer's minimum specified hardness for cured, nonreinforced resin.

j. Allowable cosmetic defects: As defined in AWWA F102.
k. Final Laminate:
   1) Thickness: Within plus or minus 10 percent of nominal laminate thickness.
   2) Tolerance: Plus 1/16 inch; minus 0 inch of minimum specified thickness.
   3) Void Content (Completed Laminate): Maximum 2-1/2 percent of laminate by volume.

3. Manufacturers:
   a. MFG Water Treatment Products Company, Union City, PA.
   b. Warminster Fiberglass, Southampton, PA.
   c. NEFCO, Inc., Palm Beach Gardens, FL.
4. NSF approval: all fiberglass materials must be NSF approved for potable water system use.

B. Aluminum:

1. Plate, Baffles, and Support Material: Aluminum, ASTM B209 and ASTM B308/B308M, minimum 1/4 inch thick.
2. Fasteners: ASTM A193/A193M and ASTM A194/A194M, Type 316.

C. Stainless Steel:

1. Plate, Baffles, and Supports: ASTM A167 and ASTM A276, minimum 1/4 inch thick.
2. Fasteners: ASTM A193/A193M and ASTM A194/A194M, Type 316.

2.03 APPURTENANCES

A. Gasket: Closed-cell neoprene, 50 durometer, 1/4 inch thick.

B. Sealant:

1. Polyurethane base, single-component, moisture curing, ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and products:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Mameco International; Vulkem 45.

C. Anchoring: Type 316 stainless steel adhesive anchors as specified in Section 05 50 00, Metal Fabrications.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in strict accordance with the manufacturer's written instructions.

B. FRP Plates: Sand all cut edges or drilled holes greater than 3/8 inch in diameter, and seal with a non air-inhibited resin solution, as recommended by resin manufacturer.

C. Install weir plates such that weir crest is level with a maximum variation of 1/16 inch throughout its entire length.

D. Gasket:

1. Install between weir plate and concrete wall, extending from bottom of weir plate to the top of the wall.
2. Gasket shall be continuous along entire length of weir plate,.
3. Joints: Butt type, using adhesive recommended by gasket manufacturer for submerged service.

E. Sealant:

1. Clean and prepare concrete and weir plate surfaces in accordance with sealant manufacturer's recommendations.
2. Application:
   a. In accordance with manufacturer's instructions.
   b. Completely cover the interface between the weir plate and mounting surface over the full height of the weir plate.
   c. Apply sufficiently to completely fill any gaps between the weir plate and the supporting wall surface.
   d. Clean excess sealant that is forced from between the weir plate and supporting wall as the plate is tightened against the wall surface to provide a neat installation.
   e. Clean all adjacent surfaces of smears or soiling.

3.02 TESTS AND INSPECTION

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Functional Test: Demonstrate proper installation of weir plate for both water tightness and level, prior to placing unit into service, by filling unit with water to the weir crest elevation. Make adjustments as necessary to meet specification.

END OF SECTION

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SECTION 44 42 56.03
VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): E101, Vertical Turbine Pumps-line shaft and submersible Types
2. American Bearing Manufacturers Association (ABMA):
   a. 9, Standard for Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Standard for Load Ratings and Fatigue Life for Roller Bearings.
3. American Petroleum Institute (API):
   a. 610, Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industry Services.
   b. 670, Machinery Protection Systems.
4. ASTM International (ASTM:
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A536, Standard Specification for Ductile Iron Castings.
   c. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
5. Hydraulic Institute Standards (HIS):
   a. 2.6, Vertical Pump Tests.
   b. 9.6.4, Vibration Measurements and Allowable Values for Centrifugal and Vertical Pumps.
6. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
7. NSF International (NSF): 61, Drinking Water System Components – Health Effects.
8. Telecommunications Industry Association (TIA): 422, Electrical Characteristics of Balanced Voltage Differential Interface Circuits.

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions.
4. Pump maximum downthrust or upthrust in pounds.
5. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, size and locations of connections and weights of components.
6. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, parts nomenclature, and materials of construction lists.
7. Baseplate drawings with leveling jackscrew details, anchor bolt and sleeve details, and minimum foundation installation and leveling requirements.
8. Power and control wiring diagrams, including terminals and numbers.
9. Complete motor nameplate data, as defined by NEMA, motor manufacturer, including motor modifications.
10. Factory finish system.
11. Vibration monitoring system information including technical product bulletins and descriptions, specification data sheets, wiring diagrams, communications hardware and software, documentation sufficient for configuration of functions specified herein and shown on Drawings.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance that factory finish system is identical to requirements specified herein.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Factory Functional and Performance Test Reports and Log. Factory test data for each pump shall be submitted, reviewed, and approved by Engineer prior to shipment of equipment.
5. Suggested spare parts list to maintain equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.

6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
8. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
9. Certification that the equipment meets the requirements of NSF 61.

1.04 EXTRA MATERIALS

A. Furnish for each set of pumps:

1. Complete set bearings.
2. Complete set gaskets and O-ring seals.
3. Complete set keys, dowels, pins, etc.
4. Complete mechanical seal.
5. One complete set of any special tools required to dismantle pump.

PART 2 PRODUCTS

2.01 GENERAL

A. Adjustable Speed Drives:

1. The pump manufacturer shall furnish coordinated operating system complete with pump, drive, and speed controller.
2. The pump manufacturer shall coordinate pump and motor requirements with adjustable speed drive manufacturer and be responsible for the complete assembly including for the following:
   a. Torsional vibration of the rotating assembly and related stresses.
   b. Motor thermal rating.
   c. Structural design of pump and motor assembly.
   d. Drive capacity for actual motor's nameplate current rating being supplied.
   e. Minimum motor speed rating for required corresponding torque.

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.03 SHAFT SEALS

A. Sealing system for vertical turbine pump shafts shall be mechanical seal as indicated in pump data sheet.

B. Mechanical Seal Requirements:

1. Non-fretting type requiring no wearing sleeve for the shaft.
2. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through the seal area.
3. Arrangement shall allow removal of seal without disturbing pump or driver.
4. For clear water services and solids up to 5 percent by weight, face combination shall be hard/soft. Otherwise, hard/hard faces shall be used.
5. Design such that dynamic O-ring moves towards a clean surface as face wears and springs are not in pumped fluid.
6. Stationary seal face shall be spring loaded to provide self-aligning despite stuffing box misalignment.
7. Where cartridge type mechanical seals are specified:
    a. Single, balanced, flexible stator design.
    b. Capable of 600 psig service.
    c. O-ring secondary seals and setscrew drive with three-point centering to ensure 0.003-inch maximum perpendicularity of rotary face to the shaft.
    d. Gland shall have flush port and be affixed to equipment with adjustable tabs to fit irregular bolt patterns.
    e. Manufacturers and Products:
        1) A.W. Chesterton Company; 155.
        2) Crane; 1B.
8. Seal Materials:
    a. Metals:
        1) Loaded Parts Over 0.060-inch Cross Section: Type 316 stainless steel minimum.
        2) Thinner Parts (springs): Hastelloy-C, Alloy 20, AMS5876 Elgiloy, or other alloy that is not vulnerable to chloride stress corrosion.
    b. Elastomers: Fluorocarbon Viton preferred unless seal manufacturer recommends ethylene propylene for service conditions.
    c. Faces: Homogeneous construction. Surface treatments and plated faces are unacceptable.
        1) Acceptable hard faces include nickel bound tungsten carbide, self sintered silicon carbide, reaction bonded silicon carbide, or graphitized silicon carbide. Silicon carbide is preferred because of its higher pressure-velocity capability.
        2) Acceptable soft face is carbon-graphite, either Union Carbide 658RC or Purecarbon P8412.

9. Seal Environmental Controls:
   a. Pipe seal flush port drain to drain as shown on Drawings with a 1/8-inch orifice plate in the line. Provide venting of seal chamber.
   b. Material of construction shall be Type 316 stainless steel.
   c. Connect mechanical seal to water purge supply where indicated on Drawings.

2.04 VIBRATION AND TEMPERATURE TRANSDUCERS AND MONITORING SYSTEM

A. General:

1. Meet requirements specified herein and with motor temperature and vibration sensors specified in Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide temperature and vibration monitoring systems in cabinet as shown in Process and Instrumentation Diagram (P&ID), program, test, calibrate, fully configure and place into operation. Vibration and temperature monitoring system shall be connected to and coordinated with the Water Treatment Plant SCADA System.
3. Monitoring system shall include a minimum of four (4) vibration inputs and four (4) temperature inputs.

B. Monitoring System Functionality:

1. The online monitoring system shall be capable of measuring, collecting, archiving, and displaying machine health data. The system shall be employed for the purpose of predictive maintenance planning and immediate retrieval of live data when required. Live data is defined as any data collected in the past 10 minutes.
2. Machine health data shall be collected by permanently mounted sensors.
3. The data collected shall be available for display anywhere in the world via internet connection for users with proper login credentials (user ID and password). The loading of software to a PC for purposes of viewing the archived data is unacceptable. The only software needed shall be a web-browser.
4. The online condition monitoring system shall be suitable for use on any machine with a rotating shaft.
5. The system shall generally consist of the following items:
   a. Sensors: Measure data on monitored machine.
   b. Data Monitors: Collect data located at or near the machine and then wirelessly transmit data through ratios up to a communication module/internet gateway.

c. Communication Module/Internet Gateway: Collects local data from data monitors (up to 50) and relays information up to an internet server, managed by manufactured, through an internet connection.
d. Graphical User Interface (GUI): Internet accessed, using a standard web browser. Displays archived and live data allows for manipulation of alarm and warning settings. The graphical user interface also serves to remotely configure and set up the system.

6. The online conditioning monitoring system shall be designed such that the only communication cables required are between the sensors and the data monitor. Communication between the monitored machine and the communication module shall be wireless. The communication to the internet shall be available, at a minimum, through a cell modem and through a wired Ethernet connection (compatible with DHCP and static IP).
7. The architecture shall be designed as a star topology and point to point communication. It shall be able to handle up to 30 data monitors with one communication module when radio communication in the environment allows.
8. The system shall employ user selectable warning and alarm settings for each data channel. Warnings and alarms shall be annunciated to the GUI, DM status LEDs, local relay, and user defined email notifications.
9. 9. Archived and live vibration spectral data or also known as Fast Fourier Transforms (FFT) shall be available on demand, schedule, and on alarm through the GUI. The FFTs shall be available in at least 1000 lines of resolution for scheduled and alarm triggered FFTs or at least 4000 lines of resolution for user requested FFTs.
10. Time-waveform data (TWF) shall be available with user requested FFTs. The GUI shall display FFT data, TWF data, or both.

C. Monitoring System Components:

1. Sensors: These sensors shall be available as required by the monitored machine.
   a. Vibration: Each vibration sensor shall be capable of measuring machine vibration in the X, Y, and Z axes. The vibration sensors shall be of (3) three axis design. Sensors with only (1) one or (2) two axes are not acceptable. Each vibration sensors shall also have an integrated temperature sensor.
      1) Operational Temperature Range: -40 degrees F to 185 degrees F.
      2) Frequency Range (X, Y, Z): 6 Hz to 4000 Hz.
      3) Vibration Reading Accuracy: +/- 10 percent.

b. Temperature: Temperature sensors shall be integral to vibration sensors.
    1) Operational Temperature Range: -40 degrees F to 185 degrees F.
    2) Temperature Reading Accuracy: +/- 5 degrees F.
c. Speed: An optional tachometer measures the speed of a rotating shaft. Speed range shall be 0 rpm to 7,200 rpm.

2. Data Monitors (DMs): DMs are mounted near the machine to monitored. DMs shall have the following as a minimum:
    a. DMs shall have 22 available data inputs:
        1) 12 – Vibration inputs.
        2) 4 – Temperature inputs.
        3) 1 – Speed input.
        4) 3 – Analog process inputs (4 to 20 mA).
        5) 2 – Digital process inputs.
    b. Each DM shall be able to collect data from every sensor every 5 seconds.
    c. Based on user defined dead bands the DM shall be able to decide the relevant data and alarm information to be sent up to the communication module. Deadbanding indicates ability to limit the transmitted data based on condition, magnitude change, and/or time.
    d. Each data input shall have a user defined alarm delay. This feature avoids false alarms for minor transient conditions.
    e. Each DM will be capable of calculating and transmitting vibration spectra (FFTs) to the GUI for user analysis.
    f. Each DM will have the intelligence to automatically collect FFTs based on schedule or alarm.
    g. In addition to monitoring and alarming overall sensor values, each DM shall perform vibration FFT Band Alarm calculations. Band alarms are user defined frequency range where alarms can be set. The monitoring system shall have a minimum of 10 user defined band alarms per vibration axis.
    h. A relay output shall be available for local alarm annunciation.
    i. Each DM shall be contained in NEMA 4X, IP66 rated enclosure with a reset button and LEDs for local alarm notification.
    j. Each DM shall be powered by 12-24 VDC either by a power supply or by loop power.
    k. Each DM shall be FCC compliant.

3. Communication Module/Internet Gateway: The communication module shall collect local data and send up the data to the GUI by the way of Ethernet connection. The CMs provide the following features:
    a. Act as a single point of contact with the internet.
    b. NEMA 4X enclosure.

c. FCC compliant.
d. Powered by 12 VDC from power supply or loop power.
e. Perform software updates to CM and DM remotely without local intervention.
f. Optional wireless communication with the internet through the use of cellular modems shall be available from widely recognized cellular service providers.

4. Graphical User Interface (GUI): The GUI provides graphical illustration of collected data. The GUI shall have the following feature as a minimum:
   a. Dashboards: Customizable GUI.
   b. Graphing multiple sensors and sensor types on the same plot.
   c. Trending archived data (data shall be archived for a minimum of 1 year).
   d. Customizable on demand reporting capabilities.
   e. Alarm and warning notifications sent by email or phone.
   f. System shall be automatically capture alarm logs.
   g. Notes shall be available for capturing maintenance logs along with alarm logs.
   h. Display of live and archived FFTs and TWF.
   i. Perform all commissioning and setup of the system remotely. No local access shall be required once the system is communicating and powered.
5. Installation:
   a. Mechanical and electrical installation of sensors and communicating system shall be by the contractor; however, the system configuration, software, and provisioning shall be remotely performed by the manufacturer.
   b. Once mounted and powered, the commissioning of the system shall be performed remotely and shall not require local intervention.
   c. The system shall not require local software to be installed, supported, or maintained.

D. Radial Vibration Transducer:

1. Consisting of proximity probe, calibrated extension cable, and connector.
2. Elements shall be fully protected in sealed weatherproof conduit and housing.
3. Coordinate with motor as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
4. For pump motor with sleeve bearings, radial shaft displacement proximity probe shall be permanently installed by motor manufacturer.

5. Mount probes at 90 degrees radially from one another.

E. Bearing Temperature Transducer:

1. Pump motor bearing and windings temperature sensors shall be permanently installed by motor manufacturer.
2. Monitoring system shall include four (4) temperature inputs.
3. Sensor shall be as specified in Section 26 20 00, Low-Voltage AC Induction Motors.

F. Motor Casing Velocity Transducer: As specified in Section 26 20 00, Low-Voltage AC Induction Motors.

2.05 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.

2.06 FACTORY FINISHING

A. Prepare and prime and finish coat in accordance with Manufacturer's standard: Per AWWA E-102.

2.07 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all equipment control panels furnished.

C. Factory Test Report: Include test data sheets, curve test results, certified correct by a registered professional engineer.

D. Functional Test: Perform manufacturer's standard, motor test on equipment. Include vibration test, as follows:

1. Dynamically balance rotating parts of each pump and its driving unit before final assembly.
2. Limits:
   a. Driving Unit Alone: Less than 80 percent of NEMA MG 1 limits.

b. Complete rotating assembly including coupling, drive unit, percent of limits established in the Hydraulic Institute Standards.

E. Performance Test:

1. Conduct on each pump at rated speed.
2. Perform under simulated operating conditions.
3. Test for a continuous 3-hour period without malfunction.
4. Test Log: Record the following:
   a. Total head.
   b. Capacity.
   c. Horsepower requirements.
   d. Flow measured by factory instrumentation and storage volumes.
   e. Average distance from suction well water surface to pump discharge centerline for duration of test.
   f. Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.
   g. Calculated velocity head at the discharge flange.
   h. Bowl head.
   i. Driving motor voltage and amperage measured for each phase.
5. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.

F. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

G. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for the pump and driver base. Accomplish wedging so that there is no change of level or springing of the baseplate when the anchor bolts are tightened.

C. Adjust pump assemblies such that driving units are properly aligned, plumb, and level with driven units and interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. Vibration and Temperature Transducers:

1. Install in accordance with API 670.
2. Install two terminal junction boxes mounted on motor housing.
3. Install conduit and cable from motor bearing temperature transducers to one of the terminal junction boxes. Install conduit and cable from motor vibration transducers to the other junction box.
4. Install Display Module in accordance with manufacturer's recommendations. Display modules for duplicate pumps shall be mounted adjacent to each other.

F. Connect suction and discharge piping without imposing strain to pump flanges.

G. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Vibration Test:
   a. Test with unit installed and in normal operation, and discharging to the connected piping systems at rates between low discharge head and high discharge head conditions specified, and with actual building structures and foundations provided shall not develop vibration exceeding the 80 percent of the limits specified in HIS 9.6.4.
   b. If unit exhibits vibration in excess of limits specified, adjust or modify as necessary. Unit that cannot be adjusted or modified to conform as specified shall be replaced.
3. Flow Output: Measured by plant instrumentation and storage volumes.

4. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
5. Test for continuous 3-hour period.
6. Test Report Requirements: In accordance with Hydraulic Institute Standards for Vertical Pump Tests HIS 2.6.

B. Performance Test: In accordance with Hydraulic Institute Standards.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 3 person-days for installation assistance and inspection.
2. 3 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for up classroom or Site training.
4. 2 person-days for facility startup.
5. 1 person-day for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Pump Data Sheet.

END OF SECTION

VERTICAL TURBINE PUMP DATA SHEET, 44 42 56.03-_____

Tag Numbers: **FT-GAC-1, FT-GAC-2, FT-GAC-3**

Pump Name: **GAC FEED PUMP NOS. 1, 2, AND 3**

Manufacturers and Product: (1) Peerless
(2) Flowserve Worthington
(3) Fairbanks Morse
(4) Weir Floway
(5) ITT Goulds Pumps

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): FILTERED WATER

Pumping Temperature (Fahrenheit): Max 85 Min 32

Specific Gravity at 60 Degrees F: 1.001 Viscosity Range: ________

Abrasive (Y/N) N Caused by: ________

Possible Scale Buildup (Y/N): N Caused by: ________

Corrosive (Y/N): N Caused by: ________

Total suspended solids (mg/L) NA.

Largest diameter solid pump can pass (inches) NA.

Altitude (Feet above Mean Sea Level): 769

Location: Indoor (Y/N): **Y** Outdoor (Y/N): **N**

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 15,300 Secondary: 9000 Total
Dynamic Head (Ft): Rated: 43.7 Secondary: 42.6

Maximum Shutoff Pressure (Ft): 80

Min. Pump Hydraulic Efficiency at Rated Capacity (%): 86.

Max. NPSH Required at Rated Capacity (Ft. Absolute): 11.3

Max. Pump Speed at Rated Capacity (rpm): 710

Constant (Y/N): N

Adjustable (Y/N): Y

DESIGN AND MATERIALS

Pump Type: Open Line Shaft (Y/N) Y Bowl: ______
Bowl Wear Rings: Y Bowl Bearings: BRONZE

Column: STEEL, FLANGED

Line Shafting: 416 SS Max. Bearing Span (Feet): 5

Discharge Head:
Type: ABOVE BASE
Material: Fabricated Steel, ASTM A36/A36M

Discharge Nozzle Size (inches): 30 Flange Standard/Class: 150

Impeller:
Type: ENCLOSED
Material: ALUMINUM BRONZE

Impeller Wear Rings: BRONZE

Head Shaft Material: 416 SS

Shaft Sealing: Packing (Y/N) Y Mechanical (Y/N) Y
Type: Split Cartridge O-ring (Y/N) Y

Coupling: Falk (Y/N) ______ Fast: (Y/N) ______ Spring-Grid (Y/N) ______
Gear Type (Y/N) ______ Spacer (Y/N) ______
Manufacturer Standard (Y/N) Y

Baseplate Material: STEEL

Sole Plate (Y/N) Y Material STEEL Soleplate: Provide for support of pump assembly, including thrust and dynamic loads, as indicated. Top of soleplate shall be faced, drilled, and tapped for pump baseplate.

Motor Base Material: STEEL

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors 26 19 00, Medium-Voltage AC Induction Motors.)

Horsepower: 250 Voltage: 460 Phase: 3

Synchronous Speed (rpm): 710

Service Factor: 1.15

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Enclosure: DIP _____ EXP ______ ODP ______ TEFC ______ CISD-TEFC ______
TEWAC ______ WPI X WPII ______

Mounting Type: Vertical Hollow Shaft YES Nonreverse Ratchet (Y/N) Y
Vertical Solid Shaft __________

ABMA 9 and ABMA 11, B-10 Motor Bearing Life (hrs): 40,000

Adjustable Speed Drive Range:. See Section 26 29 23, Low Voltage Adjustable Frequency Drive Systems.

VERTICAL TURBINE PUMP DATA SHEET, 44 42 56.03-____

Tag Numbers: FT-FIL-BW-1, FT-GAC-BW-1

Pump Name: FILTER BACKWASH PUMP NO. 1, GAC BACKWASH PUMP NO.1

Manufacturers and Product: (1) Peerless
(2) Flowserve Worthington
(3) Fairbanks Morse
(4) Weir Floway
(5) ITT Goulds Pumps

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): FILTERED WATER

Pumping Temperature (Fahrenheit): Max 85 Min 32

Specific Gravity at 60 Degrees F: 1.001 Viscosity Range: ____________

Abrasive (Y/N) N Caused by: ____________

Possible Scale Buildup (Y/N): N Caused by: ____________

Corrosive (Y/N): N Caused by: ____________

Total suspended solids (mg/L) NA.

Largest diameter solid pump can pass (inches) NA.

Altitude (Feet above Mean Sea Level): 769

Location: Indoor (Y/N): Y Outdoor (Y/N): N

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 11,200 Secondary: 10,600; 9,000

Total Dynamic Head (Ft): Rated: 47.0 Secondary: 49.5; 52.5

Maximum Shutoff Pressure (Ft): 86

Min. Pump Hydraulic Efficiency at Rated Capacity (%): 88

Max. NPSH Required at Rated Secondary Capacity (Ft. Absolute): 13.5

Max. Pump Speed at Rated Capacity (rpm): 880

Constant (Y/N): _N____

Adjustable (Y/N): _Y____

DESIGN AND MATERIALS

Pump Type: Open Line Shaft (Y/N) _Y__Enclosed Line Shaft (Y/N) _N__

Bowl: ___CI_______ Bowl Wear Rings: _BRONZE__ Bowl Bearings: BRONZE___

Column: _24_ Line Shafting: 416 SS_ Max. Bearing Span (Feet): _5___________

Line Shaft Bearings: Fluted synthetic rubber with bronze, ASTM B584 C90500, shells_____Y_______

Discharge Head:

Type:_ABOVE BASE—FABRICATED STEEL_____________________

Material: Fabricated Steel, ASTM A36/A36M Cast Ductile Iron, ASTM A536, Grade 60-40-18

Discharge Nozzle Size (inches): _24______ Flange Standard/Class: _150__________

Plain End (Y/N): ___N___Thrust Tie Lugs (Y/N): _N____

Suction Can (Y/N): _N____Can Nominal Diameter (Inches): _NA_____
Can Material: ____NA_______ Suction Can Bottom Elevation and Suction Nozzle Location as Shown on Drawings.

Impeller:

Type: _ENCLOSED___________________________________

Material: _ALUMINUM BRONZE___________________________

Impeller Wear Rings: _BRONZE_________________________________

Head Shaft Material: _416 SS____________

Shaft Sealing: Packing (Y/N) _N__________ Mechanical (Y/N) _Y___________
Type: Split Cartridge O-ring (Y/N) _Y__________________

Coupling: Falk (Y/N) ______ Fast: (Y/N) ______ Spring-Grid (Y/N) ______
Gear Type (Y/N) ______ Spacer (Y/N) ______
Manufacturer Standard (Y/N) ____Y__

Baseplate Material: ___________________________________

Sole Plate (Y/N) ___Y________ Material ____STEEL________Soleplate: Provide for support of pump assembly, including thrust and dynamic loads, as indicated. Top of soleplate shall be faced, drilled, and tapped for pump baseplate.

Motor Base Material: STEEL

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors 26 19 00, Medium-Voltage AC Induction Motors.)

Horsepower: 200 Voltage: 460 Phase: 3

Synchronous Speed (rpm): 900

Service Factor: 1.15

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Enclosure: DIP _____ EXP ______ ODP ______ TEFC ______ CISD-TEFC ______ TEWAC ______ WPI X WPII ______

Mounting Type: Vertical Hollow Shaft X Nonreverse Ratchet (Y/N) X
Vertical Solid Shaft __________

ABMA 9 and ABMA 11, B-10 Motor Bearing Life (hrs): 40,000

Adjustable Speed Drive Range:. See Section 26 29 23, Low Voltage Adjustable Frequency Drive Systems.

VERTICAL TURBINE PUMP DATA SHEET, 44 42 56.03-____

Tag Numbers: FT-SW-P-1 & FT-SW-P-2

Pump Name: SLURRY WATER PUMP NOS. 1 & 2

Manufacturers and Product:
(1) Peerless
(2) Flowserve Worthington
(3) Fairbanks Morse
(4) Weir Floway
(5) ITT Goulds Pumps

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): FILTERED WATER

Pumping Temperature (Fahrenheit): Max 85 Min 32

Specific Gravity at 60 Degrees F: 1.001 Viscosity Range: ____

Abrasive (Y/N) N Caused by: ____

Possible Scale Buildup (Y/N): N Caused by: ____

Corrosive (Y/N): N Caused by: ____

Total suspended solids (mg/L) NA.

Largest diameter solid pump can pass (inches) NA.

Altitude (Feet above Mean Sea Level): 769

Location: Indoor (Y/N): Y Outdoor (Y/N): N

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 120 Secondary: 120

Total Dynamic Head (Ft): Rated: 266.5 Secondary: 46

Maximum Shutoff Pressure (Ft): 420

Min. Pump Hydraulic Efficiency at Rated Capacity (%): 72

Max. NPSH Required at Rated Capacity (Ft. Absolute): 9.6

Max. Pump Speed at Rated Capacity (rpm): ____

Constant (Y/N): N

Adjustable (Y/N): Y

Reverse Rotation: Pump shall be capable of operating at runaway speed in reverse rotation without damage.

DESIGN AND MATERIALS

Pump Type: Open Line Shaft (Y/N) Y Enclosed Line Shaft (Y/N) N

Bowl: CI Bowl Wear Rings: BRONZE Bowl Bearings: BRONZE

Column: STEEL-FLANGED Line Shafting: 416 SS Max. Bearing Span (Feet): 5

Line Shaft Bearings: Fluted synthetic rubber with bronze, ASTM B584 C90500, shells Y

Discharge Head:
Type: ABOVE BASE—CAST IRON/STEEL
Material: Fabricated Steel, ASTM A36/A36M Cast Ductile Iron, ASTM A536, Grade 60-40-18

Discharge Nozzle Size (inches): 4 Flange Standard/Class: 125#

Plain End (Y/N): N Thrust Tie Lugs (Y/N): N

Suction Can (Y/N): N Can Nominal Diameter (Inches): NA
Can Material: NA Suction Can Bottom Elevation and Suction Nozzle Location as Shown on Drawings.

Impeller:
Type: ENCLOSED
Material: ALUMINUM BRONZE

Impeller Wear Rings: BRONZE

Head Shaft Material: 416 SS

Shaft Sealing: Packing (Y/N) ______ Mechanical (Y/N) Y
Type: Split Cartridge O-ring (Y/N) Y

Coupling: Falk (Y/N) ______ Fast: (Y/N) ______ Spring-Grid (Y/N) ______
Gear Type (Y/N) ______ Spacer (Y/N) ______
Manufacturer Standard (Y/N) Y

Baseplate Material: ______

Sole Plate (Y/N) _____Y_______ Material ____STEEL________Soleplate: Provide for support of pump assembly, including thrust and dynamic loads, as indicated. Top of soleplate shall be faced, drilled, and tapped for pump baseplate.

Motor Base Material: _STEEL______________________________________

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors 26 19 00, Medium-Voltage AC Induction Motors.)

Horsepower: _15______ Voltage: __460__________ Phase: _3________________

Synchronous Speed (rpm): _3600_______________________________________

Service Factor: 1.15____

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Enclosure: DIP _____ EXP ______ ODP ______ TEFC ______ CISD-TEFC ______ TEWAC ______ WPI __X_____ WPII ______

Mounting Type: Vertical Hollow Shaft _X______ Nonreverse Ratchet (Y/N) _Y__
Vertical Solid Shaft ___________

ABMA 9 and ABMA 11, B-10 Motor Bearing Life (hrs): _40,000________________

Adjustable Speed Drive Range: . See Section 26 29 23, Low Voltage Adjustable Frequency Drive Systems.

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SECTION 44 42 56.04
SUBMERSIBLE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American Society of Mechanical Engineers (ASME): B16.1, Cast Iron Pipe Flanges & Flanged Fittings, Class 125.
3. ASTM International (ASTM):
   a. A48, Standard Specification for Gray Iron Castings.
   b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
4. Hydraulic Institute Standards (HIS).
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
7. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction, including cable seal details.
3. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump, from shutoff to maximum capacity. Indicate separately head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.

4. Power and control wiring diagrams, including terminals and numbers.
5. Motor data, in accordance with the requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
6. Factory-finish system.
7. L-10 bearing life calculations per ABMA.

B. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer's printed installation instructions.
3. Factory and Field Performance Test Reports.
4. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Furnish for this set of pumps:

1. Two sets mechanical seals.
2. One complete set of special tools required to dismantle pump.

PART 2 PRODUCTS

2.01 GENERAL

A. Submersible, vertical shaft, centrifugal non-clog type.

B. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.

C. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.

D. Pumps furnished under this section to be provided by a single manufacturer.

2.02 SUPPLEMENTS

A. Specific requirements are attached to this section as supplements.

2.03 COMPONENTS

A. Equipment consists of pump complete with motor, guide rail, anchoring brackets, base elbow, power cable, and pump lifting cable.

B. Characteristics:

1. Motor and rotating parts shall be removable from motor end of pump.
2. Mating surfaces shall be watertight and fitted with nitrile O-rings.
3. Pumps fitted with dynamically balanced non-clog impellers.

C. Lifting Arrangement:

1. Stainless steel chain, 2 feet minimum, and one "grip-eye."
2. Attach chain permanently to pump and access platform with stainless steel wire rope.
3. "Grip-eye" capable of being threaded over and engaging links of stainless steel chain so pump and motor may be lifted with "grip-eye" and independent hoist.

D. Sliding Guide Bracket:

1. Integral part of pump unit.
2. Pump unit to be guided by no less than two guide bars, or equivalent cable system, and pressed tightly against discharge connection elbow with metal-to-metal contact or through use of profile-type gasket, provided gasket is attached to pump's flange and can be easily accessed for inspection when pump is lifted out of basin.
3. Pump metal parts that come into contact with guide rail or cable system shall be made of non-sparking materials.

E. Motor nameplate horsepower not to be exceeded at head-capacity point on pump curve.

F. Pump motor and sensor cables shall be suitable for submersible pump application and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.

G. Cable Entry System:

1. Junction chamber and motor separated by stator lead sealing gland or terminal board that prevents foreign material entering through pump top.
2. Utilize cable with factory-installed sealing gland with nonshrink epoxy seal system.
3. O-ring compression seal between sealing gland and cable entry point shall also be acceptable.

2.04 CONTROL PANEL

A. Local control panel per the Drawings and Section 40 90 00.

2.05 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 3/8-inch die-stamped equipment tag number securely mounted in readily visible location.

B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

2.06 FACTORY FINISHING

A. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Manufacturer's standard epoxy system for continuous submergence in corrosive water.

2.07 SOURCE QUALITY CONTROL

A. Pump:

1. Factory Performance Test:
   a. In accordance with HIS 11.6, Level B for submersible pump tests.
   b. Include test data sheets and curve test results.
2. Conduct on each pump.
3. Perform under actual or approved simulated operating conditions.
   a. Throttle discharge valve to obtain pump data points on curve at 2/3, 1/3, and shutoff conditions.
   b. Monitor vibrations throughout the testing and compare to HIS requirements. Modify as required.

B. Submersible Motor Functional Test: In accordance with HIS 11.6.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Mount the discharge elbow to the floor of the EQ basin floor with stainless steel bolts.

C. Connect piping without imposing strain to flanges.

D. No portion of pump shall bear directly on floor of sump.

3.02 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Flow Output: Measured by plant instrumentation and storage volumes.
3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
4. Test for continuous 3-hour period.
5. Test Report Requirements: In accordance with Hydraulic Institute Standards for submersible pump tests HIS 1.6 and 11.6.

B. Vibration Test:

1. Test with units installed and in normal operation, and discharging to connected piping systems at rates between low discharge head and high discharge head conditions specified, shall not develop vibration exceeding limits specified in HIS 11.6.
2. If units exhibit vibration in excess of limits specified adjust or modify as necessary. Units that cannot be adjusted or modified to conform as specified shall be replaced.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance and inspection.

2. 1 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-days for prestartup classroom and Site training.
4. 1 person-days for facility startup and training. Training shall not commence until accepted detailed lesson plan for each training activity has been reviewed by Engineer.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Data Sheets: Pump and motor.

END OF SECTION

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-__________________

Tag Numbers: FT-EQ-P-1, FT-EQ-P-2

Pump Name: EQ PUMP NOS. 1 AND 2

Manufacturer and Model Number: (1) FLYGT (ITT CORP)
(2) Approved Equal

SERVICE CONDITIONS

Liquid Pumped (Material and Percent Solids): GAC CONTRACTOR BACKWASH WATER

Pumping Temperature (Fahrenheit): Normal: _____ Max 90 Min 32

pH: 6.5 TO 8.0

Abrasive (Y/N) YES (GAC) Possible Scale Buildup (Y/N): NO

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 3300 Secondary: 3720

Total Dynamic Head (Ft): Rated: 49.1 Secondary: 43.5

Maximum Shutoff Pressure (Ft): 100

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%): 71%

Max. Pump Speed at Rated Capacity (rpm): 1185 Constant (Y/N): Y
Adjustable (Y/N): N

DESIGN AND MATERIALS

Pump Type: Heavy-Duty Nonclog (Y/N) Y

Volute Material: Cast Iron ASTM A48

Pump Casing Material: Cast Iron ASTM A48

Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N) Y Material: Cast Iron

Wear Ring Impeller (Y/N): Y Material: Stainless steel

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-______________________

Tag Numbers: FT-EQ-P-1, FT-EQ-P-2

Pump Name: EQ PUMP NOS. 1 AND 2

Elastomers: Nitrile Rubber

Fasteners: Stainless Steel

Impeller: Type: Double-Shrouded Non-Clog (Y/N): Y Other: ________
Material: Cast Iron ASTM A48

Shaft Material: Type 431 stainless steel

Base Elbow: Cast Iron ASTM A48

Double Mechanical Seal (Y/N): Y Bearing Life (Hrs): 100,000

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 70 Voltage: 460 Phase: 3 Synchronous Speed (rpm): 1185

Enclosure: SUB

Constant Speed

Moisture Detection Switches (Y/N): Y

Thermal Protection Embedded in Windings (Y/N): Y

REMARKS: Provide vibration sensors

SECTION 44 42 56.17
SAMPLING PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers' Association (ABMA).
2. Hydraulic Institute Standards (HIS).
3. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
4. Underwriters Laboratory (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity.
   d. Detailed drawings showing the equipment dimensions, size, and locations of connections and weights of associated equipment.
   e. Wiring diagrams, including terminals and numbers.
   f. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
   g. Factory finish system.

B. Informational Submittals:

1. Factory Functional and Performance Test Report and test log.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.

5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 EXTRA MATERIALS

A. Furnish for each pump:

1. Complete set gaskets and O-ring seals.
2. 2 stators.
3. 1 rotors.

PART 2 PRODUCTS

2.01 GENERAL

A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

B. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

2.02 SUPPLEMENTS

A. Specific requirements are attached to this section as supplements.

2.03 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.04 FACTORY FINISHING

A. Manufacturer's standard finish.

2.05 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect pump, motor and accessories for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all equipment actually furnished.

C. Factory Test Report: Include curve test results, certified correct by a registered professional engineer.

D. Functional Test: Perform manufacturer's standard, test on equipment.

E. Performance Test:

1. Conduct on each pump.
2. Conduct in accordance with Hydraulic Institute Standards.
3. Perform under simulated operating conditions.
4. Test for a continuous 3-hour period without malfunction.
5. Test Log: Record the following:
    a. Total head.
    b. Capacity.
    c. Horsepower requirements.
    d. Flow measured by factory instrumentation and storage volumes.
    e. Average distance from suction well water surface to pump discharge centerline for duration of test.
    f. Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.
    g. Calculated velocity head at the discharge flange.
    h. Field head.
    i. Driving motor voltage and amperage measured for each phase.
6. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.

F. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that the driving units are properly aligned, plumb, and level with the driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. Connect suction and discharge piping without imposing strain to pump inlet and discharge connections.

E. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. Field touch up equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Conduct tests on each pump.

B. Functional Tests:

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Vibration Test:
   a. Test with unit installed and in normal operation, and discharging to the connected piping systems.
   b. If units exhibit vibration in excess of the limits specified in HIS 9.6.4 adjust or modify as necessary. Units that cannot be adjusted or modified to conform as specified shall be replaced.

C. Performance Test: In accordance with Hydraulic Institute Standards.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. One person-days for installation assistance and inspection.
2. Two person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. Zero person-days for prestartup classroom or Site training.
4. One person-days for facility startup.
5. Zero person-days for post-startup training.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Sampling Pump Data Sheet.

END OF SECTION

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SAMPLING PUMP DATA SHEET 44 42 56.17-001

Tag Numbers: FT-FWSP-001; FT-FWSP-002

Pump Name: Finished Water Sampling Pump

Manufacturer and Model Number: (1) Moyno, Inc. 500 Series, Model 356
(2)Continental Pump Co. Model CP
(3) Or approved equal

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): 100% water

Pumping Temperature (Fahrenheit): Max 90 Min 35

Inlet Pressure at Pump (psig): suction lift under all conditions

Min. Net Positive Suction Head Available (psia): 6.15

PERFORMANCE REQUIREMENTS, FT-FWSP-001:

Rated Capacity: 16 US gpm at 22.5 psi discharge pressure.

Max. Pump Speed (rpm): 1,725 Constant (Y/N): Yes Adjustable (Y/N): No

PERFORMANCE REQUIREMENTS, FT-FWSP-002:

Rated Capacity: 16 US gpm at 26.5 psi discharge pressure.

Max. Pump Speed (rpm): 1,725 Constant (Y/N): Yes Adjustable (Y/N): No

DESIGN AND MATERIALS

Pump Body Material: Cast iron Pump Stages: One

Connections: Suction: Screwed; Discharge: Screwed

Stator Material: NBR (Nitrile) Stator Thermal Protection (Y/N): No

Rotor Material: Type 416 stainless steel

Shaft Seal: Mechanical

Drive Type: Direct-Coupled

DRIVE MOTOR

Horsepower: 1 ½ Voltage: 460 Phase: 3 Base Speed (rpm): 1,725

Service Factor: 1.0 Inverter Duty (Y/N) No

Motor nameplate horsepower shall not be exceeded at any head-capacity point on the pump curve.

Enclosure: TEFC

SECTION 44 43 30
FILTER MEDIA

PART 1 GENERAL

1.01 ALTERNATES

A. The material in specified herein shall be installed to the depths shown on the Plans between the filter underdrains and the granular activated carbon media. As a minimum, four (4) inches of filter media shall be installed above the highest part of the underdrain system.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): B100, Granular Filter Material.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Submit not less than 30 days prior to shipment manufacturer's product information, including grain size ranges for each media layer specified. Fine media sizes shall be in millimeters.
2. Samples: Submit Sample of media material following delivery of shipment.

B. Informational Submittals: Submit gradation test results of fine media, including sieve analysis prior to loading and shipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fine Media:

1. Unifilt Corp.
2. F.B. Leopold Co.
3. Anthrafilter.
4. Fairmount Minerals.

2.02 FINE MEDIA

A. Silica Sand for Water Filters: Clean, hard, durable particles in conformance with AWWA B100, modified as follows:

1. Silica sand of specific gravity 2.6, effective size 0.45 to 0.55 millimeter or as recommended by the filter underdrain manufacturer; and uniformity coefficient not more than 1.40.

2.03 SOURCE QUALITY CONTROL

A. Owner will test Samples in accordance with procedures specified in AWWA B100.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Do not permit workers to walk or stand directly on the underdrain. Use boards that will sustain workers' weight.
2. Before fine media is placed, mark top of all layers on side of filter.

B. Placing Media:

1. Clean contactor tanks before media is placed and keep tanks clean throughout placement operation.
2. Place media in a single layer as shown on the plans.
3. Place carefully by hand to avoid movement to underdrain system and to assure free passage for water from the orifices.

C. Fine Media:

1. Transport and place fine media carefully to prevent contamination of any sort.
2. Replace contaminated media with clean media.
3. Level fine media by hand to within plus or minus one-half (½) - inches of the appropriate mark prior to backwashing.
4. Install in following sequence:
   a. Place 4 inches minimum of silica sand and level.
   b. Backwash bed a minimum of three times, and remove surface fines by scraping after each washing.
   c. Replace scrapings with new material after each washing to obtain the required depth.
5. Final depth of fine media after washing and scraping shall be 4 inches.

3.02 DISINFECTION

A. After installation of media is completed, disinfect media in accordance with the requirements of Section 33 13 00, Disinfecting of Water Utility Distribution.

END OF SECTION

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SECTION 44 43 34
CONTACTOR UNDERDRAIN SYSTEM

PART 1 GENERAL

1.01 ALTERNATES

A. Dual Lateral Block and Stainless Steel Lateral are alternate underdrain systems specified herein.

B. Refer to Section 01 11 00, Summary of Work for description of Work under this section affected by alternates.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
    a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
    b. B16.5, Pipe Flanges and Flange Fittings NPS 1/2 Through NPS 25 Metric/Inch Standard.
2. ASTM International (ASTM):
    a. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
    b. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding System for Concrete.
    c. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
    d. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
    e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
3. NSF, International: 61, Drinking Water System Components—Health Effects.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. Design underdrain system, including, but not limited to, the underdrain laterals, drop legs, integral support cap and air scour header.
2. Compatible with contactor media being supplied; refer to Section 44 43 30, Filter Media and Section 43 31 13, Granular Activated Carbon (GAC) Filter Media.

3. Contactor media to consist of the following:
    a. 4-inches of filter sand, effective size of 0.45 to .055 millimeters.
    b. 12 feet of GAC Media, for FTTP
4. Flow:
    a. Produce uniform air and water flows throughout contactor box.
    b. Flow uniformity per square foot of contactor underdrain area shall be as required to permit efficient and effective operation during filtration and backwashing.
    c. There shall be no localized areas with flow rates which would cause mounding, lateral displacement, or other deleterious disturbances in media.
    d. Size air scour header and risers to produce uniform air flows throughout contactor bay.
5. System shall ensure operating characteristics have long-term stability and resistant to the following:
    a. Corrosion.
    b. Changes in head loss.
    c. Changes in flow uniformity.
    d. Other effects which would over time cause loss of efficiency or effectiveness of operation.
6. System Design Loads:
    a. Withstand net downward loading of not less than 1600 psf, plus system's own dead weight.
    b. When installed, withstand net internal loading (burst pressure) of greater than or equal to twice the maximum head loss experienced at maximum backwash rates and not less than 5 psig. No credit shall be taken for weight of contactor media.
    c. Withstand specified loadings, including anchorages and supports.
    d. Address loads incurred during shipment, delivery, storage, handling, installation, and operation.
7. Support and Restraint:
    a. Underdrain and air scour header and drop legs shall be anchored as required to resist buoyant forces and dynamic forces during operation.
    b. Underdrain laterals shall not require support or restraint to resist specified burst pressure.
    c. Safety Factor: 2.0, minimum, to account for transient pressures which may occur during initiation and termination of air and water flows during backwash.
    d. Contactor air scour header assemblies shall be designed to be supported inside of the flume.

B. System Performance Requirements:

1. As installed, shall satisfy the following criteria for minimum acceptable flow uniformity. Maldistribution of air and water flows during backwash, for all indicated flow conditions, shall not exceed:
   a. Water: Plus or minus 3 percent of average backwash rate (gpm per square foot) of contactor underdrain area for a backwash rate of 12 gpm/sf.
   b. Water: Plus or minus 4.5 percent of average backwash rate (gpm per square foot) of contactor underdrain area for a backwash rate of 6 gpm/sf.
   c. Air: Plus or minus 10 percent of average scfm per square foot of contactor underdrain area
2. Evenly distribute air, water, and combined air/water flows and perform satisfactorily when operated under the following conditions:
   a. Filtration (Downflow) Mode: Water (filtrate) at rates up to 10 gpm per square foot of contactor underdrain area.
   b. Backwash (Upflow) Mode:
      1) Air Rate:
         a) 2 scfm per square foot of contactor underdrain area for air wash only.
         b) 2 scfm per square foot concurrent with water at rates of between 2 and 6.0 gpm per square foot while overflowing backwash troughs.
      2) Water Rates: Water only backwash rates will vary from 6.0 gpm/sf to 12 gpm/sf based upon water temperatures. The underdrain system shall be designed to operate over this range of flows including the maldistribution values specified. In addition, the underdrain manufacturer shall submit calculations and narrative defining the impact of increasing the backwash rate to 18gpm/sf in the future.
3. Total water flow head loss across underdrain system, including caps, covers, or screens, shall not exceed the following:
   a. 36-inches water column (WC) of head loss when supplied with water flow of up to18 gpm per square foot at 75 degrees F in backwash mode.
   b. 18-inches water column (WC) of head loss when supplied with water flow of up to12 gpm per square foot at 75 degrees F in backwash mode.
   c. 12 inches WC of head loss when supplied with water flow of up to 5 gpm per square foot at 75 degrees F in filtration mode.
4. Water flow head losses across underdrain system shall include losses associated with underdrain and equalizing or secondary flume inside contactor bay.

a. Head losses shall include losses between lower gullet wall opening to just above integral support cap screen on top of underdrain.
b. Head losses exclude static head of water above the underdrain as well as losses through media.

5. Air flow head loss across contactor air scour header and drop legs, and underdrain laterals shall not exceed the following:
   a. 11-inches WC of head loss when supplied with concurrent air and water flows of up to 2.0 scfm per square foot of air flow and up to 5 gpm per square foot of water flow at 75 degrees F in backwash mode.
6. Air flow head losses across contactor air scour header, drop legs, and underdrains shall include losses associated with air scour header assemblies and underdrain.
   a. Head losses shall include losses from upstream flange on air scour header within contactor basin to just downstream of (above) distribution orifices in top of underdrain.
   b. Head losses exclude static head of water above underdrain.
7. Media-retaining system shall:
   a. Be compatible with underdrain system and with filter media and GAC media.
   b. Retain contactor media including both the filter media and GAC media.
   c. Be appropriate for combined air/water backwash.

1.04 SUBMITTALS

A. Action Submittals:

1. Manufacturer's catalog cuts and technical literature describing proposed underdrain system.
2. Shop Drawings: Scaled and dimensioned drawings showing layout and configuration.
3. Written interface requirements, installation details, and recommendations as are necessary to properly interface underdrain system with surrounding structures. Provide guidance in order for contactor structure to be modified to accommodate underdrain system if needed.
4. Details of design and operating characteristics of proposed contactor underdrain system. Address full range of flow conditions. Indicate pertinent physical relationships (location, relative size) among various air and water orifices, including those in lower gullet walls.

5. Include the following:
    a. Materials of construction.
    b. Head loss data for air, water, and combined air/water flows.
    c. Maximum percentage of flow maldistribution within contactor for air, water, and combined air/water flows.
    d. Cross-sectional areas for flow of air and water and resulting velocities at pertinent points (e.g., gullet, lateral, orifices) throughout underdrain system (i.e., from inside lower gullet to just above media support cap).
    e. Relative magnitudes of entrance, transport, metering, and discharge losses.
    f. Other data necessary to demonstrate conformance with requirements of Contract Documents.

B. Informational Submittals:

1. Written confirmation that media is compatible with underdrain system.
2. Certification that contactor underdrain system will satisfy specified hydraulic and pneumatic conditions and provide even distribution of air, water, and combined air/water flow at specified flow rates as fed in arrangement shown on Drawings.
3. Design calculations showing structural design requirements, including anchor bolt sizing. Structural calculations shall be stamped and signed by structural engineer registered in state of the Project.
4. Documentation showing NSF 61 certification of underdrain components, including sealing compounds, caulks, and other materials.
5. Proposed method of testing installed system.
6. Field Test Reports: Describe units tested, type of test, test set ups, procedures, instrumentation, flow rates, pressures, levels, and other data and results as required to demonstrate items tested meet specified requirements.
7. Written interface requirements, installation details, and recommendations as necessary to properly interface contactor underdrain system with surrounding structures.
8. Manufacturer's installation instructions and details.
9. Manufacturer's written confirmation contactors have been satisfactorily prepared for installation of contactor underdrain system.
10. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
11. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer's representative for field services shall be a direct employee of underdrain system manufacturer and shall have minimum of 5 years experience installing type of underdrain system specified herein.

B. Certification: Materials used in contact with water and backwash air shall meet NSF 61.

1.06 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage and adequately marked for ease of erection.

B. Equipment shall be protected from exposure to corrosive fumes and kept dry.

C. Store products in a manner that prevents damage and in an area that is protected from the weather.

PART 2 PRODUCTS

2.01 DUAL LATERAL BLOCK UNDERDRAIN SYSTEM

A. Manufacturers:

   1. Where a manufacturer's standard equipment name or model number is listed, equipment system shall be provided as modified to conform to performance, functions, features, and materials of construction as specified herein.
   2. Materials and products specified herein shall be selected and supplied by underdrain system manufacturer, unless specified otherwise.
   3. Materials, equipment, and accessories specified in this section shall be products of:
      a. F.B. Leopold Co., Inc., Zelienople, PA; Universal® Type S® Underdrain with IMS® cap.
      b. Infilco Degremont, Inc., Richmond, VA; Tetra™ U Block Underdrain with SAVAGE PLATE®.
      c. Siemens Water Technologies (General Filter), Ames, IA; MULTIBLOCK® Underdrain with MS-500 porous bead cap.
      d. Roberts Filter, Trilateral Block with media retaining cap

B. Underdrain Blocks:

1. Dual lateral type whereby parallel feeder and compensating laterals are contained within cross section of a single block.
   a. Cross section shall be arranged so feeder (or primary) lateral is adjacent and connected to compensating (or secondary) laterals through a series of orifices.
   b. Discharge of flow from top of block shall be controlled by orifices that provide uniform distribution of water during filtration and backwash.
   c. Feeder lateral shall have cross-sectional area of at least 50 square inches per block to achieve acceptable air and water transport velocities and head losses during backwash.
2. Distribution Orifices:
   a. Sized and located to provide uniform distribution of water and air.
      1) Not less than 7/32-inch diameter and shall be recessed from the surface by approximately 1/8 inch.
   b. Top of each distribution orifice shall be encircled by a depression approximately 3/8 inch by 3/4 inch.
   c. Approximately 22 per square foot of underdrain system.
3. Primary Lateral: Vented or baffled to prevent air from remaining in primary lateral during water-only portion of backwash cycle.
4. Individual Blocks:
   a. Impervious, high strength, completely inert, high density polyethylene (HDPE) material.
   b. Resistant to erosion and corrosion.
   c. Uniform, smooth surfaces.
   d. Orifices shall be properly deburred.
   e. Ridges and pockets for structural rigidity and to key into surrounding grout.
   f. Dimensions: 12 inches high by 11 inches wide, maximum, by maximum of 48 inches long.
   g. Size and weight permit ease of handling and installation.
   h. Arranged end-to-end and mechanically joined to form continuous underdrain laterals.
5. Joints:
   a. Gasketed, bell-and-spigot type with internal registers.
   b. Snap-lock type with integral interlocking snap lugs and receptors.
   c. Air and watertight.
   d. Gaskets:
      1) Supplied by underdrain system manufacturer.
      2) Made of neoprene or cross-linked closed cell polyethylene.
   e. Joining technique shall be such that no leakage (air or water) occurs with a maximum 2-degree misalignment at each joint.

6. Flume Blocks:
    a. Provide for entrance or upstream (backwash mode) end of each underdrain lateral.
    b. Accept backwash water from lower gullet wall opening during backwash and provide an equalizing or secondary flume inside contactor.
    c. Sized as required to ensure equal flow distribution among laterals.
    d. Discharge water to effluent flume during filtration.
    e. Accept air from air header located in flume from air risers.
    f. Anchors: Underdrain manufacturer shall provide angles, preshaped anchor rods (e.g., "L-rods"), epoxy adhesive system, concrete anchors, and sealant to anchor flume blocks to contactor floor. Manufacturer shall provide detailed instructions and training on the proper installation of the anchors.
    g. Support from gullet wall and seal to gullet wall.
7. End Plates: HDPE sealed to downstream end of laterals at filter wall.
8. Integral Support Cap:
    a. Constructed of HDPE plastic beads sintered together.
    b. Pore Size and Volume: Sufficient to prevent media from obstructing or passing through underdrain.
    c. Shall not increase overall underdrain height by more than 1 inch.
    d. Attached to underdrain at factory with Type 316 stainless steel screws and sealed with manufacturer's recommended caulking. A minimum of three (3) screws shall be used at all connection points.
    e. Eliminate need for, and function in lieu of, support gravel.
9. Equipment Flanges: Comply with ASME B16.1, Class 125 or ASME B16.5, Class 150, unless otherwise indicated.
10. Sleeves and Gaskets: Neoprene, 45 to 55 durometer rated for 200 degrees F.

2.02 STAINLESS STEEL LATERAL UNDERDRAIN SYSTEM

A. Manufacturers:

1. Where a manufacturer's standard equipment name or model number is listed, equipment system shall be provided as modified to conform to performance, functions, features, and materials of construction as specified herein.
2. Materials and products specified herein shall be selected and supplied by underdrain system manufacturer, unless specified otherwise.
3. Materials, equipment, and accessories specified in this section shall be products of:
    a. AWI, Sandy, UT; Phoenix Filter Underdrain System.

4. No "or-equal" or substitute products will be considered.

B. General:

1. Series of stainless steel laterals connected and sealed to stainless steel inlet/outlet flow distribution devices.
2. Laterals shall be evenly spaced and anchored onto concrete floor of each contactor.
3. Gaskets and sealants shall be NSF 61 approved.

C. Laterals:

1. Consisting of one primary water collection/backwash distribution conduit and one primary air scour distribution conduit in separate compartments.
2. Designed to independently distribute air and water during contactor backwashing.
3. Type 316L stainless steel.
4. One-piece construction with no shop bolted or riveted media barrier panels or other independent media barrier devices attached.
5. Locate individual variably sized secondary distribution orifices within each lateral to control distribution of backwash water flows along entire lateral length.
6. A calculated number of slots shall control distribution of air scour flow directly from air conduit into contactor media.
7. Media Retaining Slots: Cut directly into sides of laterals to support media without need for support gravel, while allowing passage of water for water collection and backwashing.

D. Lateral Feed Orifices: Each lateral to discharge water and provide backwash water through a single primary orifice located 1 inch, maximum, above stainless steel lateral base.

E. Equipment Flanges: Comply with ASME B16.1, Class 125 or ASME B16.5, Class 150, unless otherwise indicated.

F. Anchorage:

1. Use hold down clamps.
2. Anchors: Underdrain manufacturer shall provide anchors, epoxy adhesive system, concrete anchors, and sealant to anchor underdrain system to contactor floor. Manufacturer shall provide detailed instructions and training on the proper installation of the anchors.
3. Anchor bolts shall be epoxy bond type, sized per manufacturer's recommendations.

4. Type 316 stainless steel.

2.03 SERVICE CONDITIONS

A. Underdrain system shall operate in GAC Contactors as shown and specified.

B. Backwashing regime for contactors uses air scouring and includes air only, combined air/water, and water-only steps. At MPTP only the backwashing regime will be water only from initial installation until air supply blower system is added at some date in the future.

C. Contactor Influent:

1. Will be filtered.
2. Will be chlorinated. Maximum free chlorine residual is 1 milligram per liter.

D. Contactor backwash water will be filter effluent supplied from GAC Pump Well containing 0.2 to 1 milligram per liter of chlorine.

E. Temperature:

1. Contactor influent and backwash water are expected to be approximately 32 to 85 degrees F.
2. Air scouring air at contactor air scour header shall not exceed290 degrees F.

F. pH ranges of contactor influent and backwash water are expected to be approximately 6 to 8.5 pH units.

2.04 CONTACTOR AIR SCOUR HEADER AND RISER ASSEMBLIES AND ACCESSORIES:

A. Design each contactor with air scour piping to provide uniform distribution of air during backwash.

1. Each assembly shall include air scour header and risers as shown on Drawings.
2. Materials of Construction: Piping and supporting hardware shall meet requirements specified in Section 40 27 00, Process Piping—General. Headers and risers shall be Schedule 5 or 10, Type 316 stainless steel pipe.

B. Provide sleeves, couplings, and miscellaneous hardware to connect drop legs to flume block, as applicable.

C. Provide pipe supports/restraints, concrete anchors, and miscellaneous hardware (for example, fasteners) for header and drop pipes. Metallic components shall be Type 316 stainless steel.

D. Equipment Flanges: Comply with ASME B16.1, Class 125 or ASME B16.5, Class 150, unless otherwise indicated.

2.05 ANCHOR BOLTS

A. Anchor Bolts:

1. Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

B. Threaded assemblies shall be chemically treated or lubricated prior to assembling to prevent galling.

C. Concrete Anchors: Adhesive type.

D. Anchoring Adhesives:

1. Vinyl Ester:
    a. Two components, insensitive to moisture, designed to be installed in adverse freeze/thaw environment.
    b. Cure temperature, pot life, and workability compatible for intended use and anticipated environmental conditions.
    c. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System (HIT C-100).
2. Mixed Epoxy Adhesive:
    a. Nonsag light paste consistency with ability to remain in 1-inch diameter overhead drilled hole without runout with the following properties:
        1) Slant Shear Strength: ASTM C881 and ASTM C882; No Failure in Bond Line, Dry/Moist Conditions 5,000 psi.
        2) Compressive Strength: ASTM D695; 14,000 psi, minimum.
        3) Tensile Strength: ASTM D695; 4,500 psi.
        4) Heat Deflection Temperature: ASTM D648; 135 degrees F, minimum.
    b. Manufacturers and Products:
        1) Adhesives Technology Corp., Kent, WA; Anchor-It Fastening System, HS 200 Epoxy Resin.
        2) ITW Ramset/Red Head, Paris, KY; Epcon Ceramic 6 Epoxy Anchor System.

E. Wedge or expansion anchors shall not be acceptable.

2.06 GROUT

A. Furnish and install grout as recommended by the underdrain manufacturer.

2.07 CONCRETE

A. As specified in Section 03 30 00, Cast-in-Place Concrete.

2.08 REINFORCING STEEL

A. As specified in Section 03 21 00, Reinforcing Steel.

2.09 SPECIAL TOOLS

A. Provide special tools and lubricants needed to install underdrain system.

2.10 FABRICATION

A. Metals below top of contactor box wall shall be Type 316 stainless steel. Hot dipped galvanized steel shall not be acceptable.

B. Metallic components shall be premanufactured (for example, concrete anchors) or shop fabricated (for example, air scour header assemblies) components. Field fabrication, bending, cutting, or welding shall not be acceptable.

C. After fabrication, pickle and passivate stainless steel assemblies and parts according to ASTM A380.

2.11 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Notify Engineer at least 2 weeks prior to testing so Engineer or Owner can, at their option, witness testing.
2. Provide written report summarizing factory test results signed and sealed by a professional engineer.

B. Prior to shipment from factory, test one out of every 400 blocks, with integral support caps and a minimum of 0.25% of the stainless steel underdrains, for head loss and uniform distribution of air and water. Results of tests shall be within 10 percent of manufacturer's published and/or specified values.

C. Prior to shipment from factory test one full length lateral for head loss and uniform distribution of air and water. Test lateral in a test cell capable of isolating and physically measuring flow rates at 24-inch intervals. Head loss shall also be measured at 24-inch intervals. Results of the head loss and dispersion tests shall conform to the specified values.

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to commencement of installation of underdrain system, manufacturer's representative shall inspect contactor preparation work and provide written confirmation that contactors are satisfactorily prepared for the installation of air scour and underdrain system.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer's instructions, recommendations, and interface requirements with surrounding structures, including requirements for grouting keys and pockets, dowels, support ledges and piers, anchorage.
2. Install adhesive anchors in accordance with adhesive manufacturer's recommendation.

B. Cleaning:

1. Remove debris and sand from contactor gullets and power wash inside of gullet.
2. Take precautions recommended by underdrain manufacturer or specified herein to ensure contactor underdrain system and associated piping and conduits are completely clean and free of debris, dirt, or other foreign materials which could clog underdrain system or interfere with flow.
3. Flush backwash air piping and recessed flume.
4. Remove loose debris and dirt within contactor cell and flume by brooming down and vacuuming.
5. Engineer and contactor underdrain manufacturer's representative shall approve cleaning before Contractor may begin placement of contactor media.

C. Protection:

1. As installation progresses, protect partially completed portions of the Work to maintain cleanliness of underdrain system.
2. Maintain protection until media is installed.

D. Dual Lateral Block Contactor Underdrain System:

1. Do not use blocks with warped surfaces or uneven orifices, or blocks that are cracked or otherwise damaged.
2. Set blocks level in fresh grout over entire bottom.
3. Spaces between blocks of adjoining underdrain laterals and spaces between underdrain lateral and contactor box walls shall not exceed 3 inches.
4. Exercise care in preparing contactor floor slab and in setting anchors to ensure proper alignment and elevation. Screen slab to flat level plain and be free from protrusions and depressions.
5. Install plates and gaskets at ends of each row of blocks.
6. Locate gaskets at expansion joints and couplings to form airtight connection at 20 psig minimum.
7. Install anchor rods. Dowel to concrete per manufacturer's recommendations.
8. Flume blocks shall not be modified in field except under direct supervision of manufacturer's representative.
9. Grout:
    a. After blocks have been set and carefully aligned, grout spaces between rows and ends of blocks and walls.
    b. Prevent grout from entering laterals, orifices, integral support cap pores, or from being deposited in a manner that would interfere with distribution and dispersion of flow.
    c. Cure for minimum of 3 days before placing contactor media or performing backwash tests.

E. Stainless Steel Lateral Underdrain System:

1. Set in place and anchor to position in a true and level plane within tolerance specified by underdrain system manufacturer.
2. Continuously monitored levelness during placement.
    a. Level measurement and monitoring shall be by means acceptable to Engineer.
    b. Failure of underdrain section to meet required level tolerance shall require removal of failed sections and replacement with new sections to within level tolerances.

3. Lateral Feed Orifices:
   a. Install laterals over a reinforced flow adaptor feed box receiving flow along length of recessed flume.
   b. Size primary orifices onsite by dynamic hydraulic profiling utilizing a minimum of six flow measurement devices simultaneously measuring backwash flow in a series of tests.

F. Grout:

1. Place and cure nonshrink grout as directed by grout and underdrain manufacturers.
2. Keep grout out of orifices and flow passages and prevent grout from being deposited where it could interfere with flow.

3.03 TESTS AND INSPECTIONS

A. Perform backwash and down flow tests on completed system following installation of underdrain system, curing of concrete and grout, and prior to placing contactor media.

B. Perform tests in both downflow and backwash (upflow) modes at specified rates to confirm hydraulic performance is in compliance with this Section.

C. Check for and correct leaks and nonuniform flow of backwash water and air, structural instability, or other defects.

D. During backwash test, visually observe for signs of dead spots or boils. Evidence of flow maldistribution such as a water “mound” or “boil” in contactor will constitute a failed test.

E. If defects require correction, retest as necessary until results are acceptable to Engineer.

F. Test Report: State results of tests, procedures used, details of adjustments made to unit, and precautions to be taken to ensure proper and safe operation and maintenance of unit.

G. Underdrain system manufacturer’s representative shall not furnish a Certificate of Proper Installation until representative is satisfied underdrain system has been properly installed and functionally tested and that detrimental affects of subsequent contactor media placement have been remedied.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:

1. 1 person-days for inspection of each contactor prior to installation of underdrain system.
2. Supervise, observe and inspect the entire installation of the underdrain system in the first contactor.
3. 8 additional person-days for installation assistance inspection. 6 additional days for MPTP.
4. Supervise and observe all functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
5. 1 person-days for prestartup classroom or Site training.
6. 1 person-days for facility startup.
7. 1 person-days for post-startup training of Owner's personnel.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

SECTION 44 44 73
UV SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of references which may be found in this section:

1. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
3. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
4. U.S. Environmental Protection Agency (USEPA):
   a. Final UV Disinfection Guidance Manual (UVDGM) - 2006 UVDGM.

1.02 DEFINITIONS

A. UV Dose (Fluence): Shall indicate the UV power incident onto an infinitesimally small sphere of cross-sectional area d*A*, divided by d*A*, for a given contact time in seconds. The units of UV dose are millijoules per square centimeter (mJ/cm^2). The term "UV dose" shall only include the UV energy with germicidal properties, and the contributions shall be weighted according to the relative spectrum of germicidal effectiveness for the challenge organism utilized by the Supplier in Validation Testing.

B. UV Transmittance (UVT): Shall indicate the transmittance of ultraviolet light at a wavelength of 254 nanometers through the water across a path length of 1 centimeter. UVT shall be expressed as a percentage.

C. Intensity: Shall indicate the intensity of UV energy and shall be defined as the UV power incident onto an infinitesimally small sphere of cross-sectional area d*A*, divided by d*A*. The units of intensity are milliwatts per square centimeter (mW/cm^2).

D. Reduction Equivalent Dose (RED): Shall indicate the dose necessary, with the full-scale UV System to provide a level of inactivation of a specific organism (e.g. MS-2 bacteriophage) equivalent to the level of inactivation for the same organism achieved in a laboratory, using a collimated beam apparatus with a low-pressure lamp producing UV energy at a wavelength of 254 nanometers, on a water sample collected at the same time.

E. Validation Factor (VF): As defined by the UVDGM, an uncertainty term that accounts for the uncertainty and bias associated with validation testing.

F. As defined in Section 00 72 10, General Conditions.

1.03 SYSTEM DESCRIPTION

A. The existing water treatment system includes chemical treatment, settling and sand filtration.

B. The UV System will be installed downstream of granular activated carbon (GAC) adsorption. The GAC adsorption is being newly installed at the same time as the UV system.

C. The UV System will be installed inside a new AT (Advanced Treatment) Building. The Main and Local Control Panel will be installed on a platform in the same room as the UV Reactors. The temperature inside the building is expected to be maintained between 50 and 78 degrees F.

D. The maximum, minimum, and average flow rates are shown in the UV Data Table at the end of this Section.

E. Estimated characteristics of the GAC effluent water is based on measured parameters for finished water, and are shown in the UV Data Table at the end of this Section.

1.04 SUBMITTALS

A. The following specific information shall be provided in accordance with the General Requirements:

1. Shop Drawings:
   a. Catalog information and cuts for all system components, including the control system components and control panels.
   b. Detailed shop drawings of all system components and all interconnections and interface requirements (piping, power, control, instrumentation, data), dimensions of all major elements of the UV System, critical clearance requirements, and weight of equipment.
   c. Input power requirements; clearly specify whether 480V, 3-wire or 480/277V, 4-wire is required as well as ampacity. Also state the maximum time duration of AC power loss that the local control panel (LCP) can ride through before functional shutdown as well as equipment power operating range, voltage and frequency.
   d. Information on the details of sensor calibration and traceability, sensor uncertainty (including uncertainty from linearity, temperature response, spectral response, angular response, and

long-term drift), polychromatic bias, working range, detection limit, sensor life and sensor calibration interval showing compliance with the 2006 UVDGM. Also provide expected variations among online sensors readings.

e. Complete description of sensor locations within reactor and accessibility for calibration and routine maintenance.

f. A list of all system components along with their expected replacement frequencies, and duration of life warrantees. Include a list of special tools required for checking, testing, parts replacement, and maintenance.

g. Lamp data, including, watt rating, initial lumen output, lamp loss factors, average lumens and life expectancy (in hours).

h. Complete description of the manual or automatic lamp cleaning mechanism and its maintenance requirements. The level of details should be sufficient for Owner to evaluate lamp cleaning mechanism reliability and its maintenance requirements.

i. Operator Interface Units (OIU) example screens and Programmable Logic Controller (PLC) programs on CD in Rockwell Automation and pdf formats.

    1) Fully documented ladder logic listings, function listings for function blocks not fully documented by ladder logic listings, cross-reference listings and operator interface configuration documentation.

j. Complete description of UVT monitor. Include operation and maintenance requirements necessary for compliance with the 2006 UVDGM requirements.

k. Control Approach: Written description of control approach.

l. Validation Testing: Detailed report with third party signature, raw data, and documentation of all reactor performance validation testing per the 2006 UVDGM. Include dose equations, target organism, validation factor, including all applicable components, and RED at operating conditions as described in the Contract Documents as assembled herein. If reactor was validated to a previous version of the UVDGM, provide summary of deviations from the 2006 UVDGM and indicate if additional validation testing per the 2006 UVDGM is required and/or planned. Describe control approach. Provide inlet and outlet piping configurations from validation testing. Completed checklists 5.1, 5.2, 5.3 and 5.4 from the 2006 EPA UVDGM. Note: The State reviewing agency will be performing its review in accordance with Checklist 5.5 of the 2006 UVDGM. The UV System manufacturer shall provide all information necessary to satisfy the requirements listed in Checklist 5.5 and any additional information requested from the State reviewing agency that is referenced as required documentation in the 2006 UVDGM. The

UV System shall have been validated at the operating conditions described in the Contract Documents as assembled herein.

m. Headloss information on proposed reactor at maximum and average flow rates. Headloss shall be calculated from the inlet flange to the outlet flange of the reactor, including any baffling or required flow conditioner plates.
n. Third-party certification of lamp aging and quartz sleeve fouling factors.
o. Harmonic distortion data, up to the 35^{th} harmonic, and power factors at ballast's minimum, medium, and maximum power settings. Include test data showing that the available short circuit current at the Main LCP input power terminals to be 30,000 amps symmetrical at 480 volts and include distortion by harmonic table. 3^{rd} party off-site test results are acceptable.
p. Data on harmonic filters, or active filters, used to mitigate harmonics to IEEE 519 levels.
q. Detailed engineering calculations showing efficiencies of electrical components and power requirements per each Local Control Panel (LCP) provided.
r. Wireway, conduit and grounding layout Drawings, wiring and control diagrams, and the overall electrical design of the UV System (both control and power).
s. Specifications for all interconnecting cables between the UV equipment, including voltage ratings, insulation type, conductor material and cable/conductor outside diameter.
t. Interconnecting cable termination data, including termination type and quantity.
u. Control panel construction and panel layout Drawings.
v. Control panel interconnection wiring diagrams that include numbered wire and terminal designations showing all external interfaces.
w. Special shipping, storage and protection, and handling instructions.
x. Provide structural calculations for the UV System and the UV System supports and anchoring, designed and provided by the Supplier. Supplier shall design and provide all supports directly supporting the UV Reactors (does not include supports for upstream and downstream piping). All structural calculations shall meet the requirements of the local building code and signed by a registered Professional Engineer in the Structural or Civil discipline.
y. Manufacturer's printed installation instructions.
z. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

2. Quality Control Submittals:
   a. Documentation of lamp outputs prior to shipment of equipment. Supplier will verify the output of up to four (4) lamps for MP systems.
   b. Factory test procedures and data sheets.
   c. Factory Witness Test Report: Provide report as indicated; UV equipment may not be shipped until the report is approved by the Engineer.
   d. Detailed proposed procedure for conducting the functional and performance field tests.
   e. Functional Testing Report: Provide a narrative of the Functional Testing discussing each element requiring testing, the tests performed, and the results. Functional Testing is not complete until this report is submitted and approved by the Engineer.
   f. Performance Testing Report: Provide a narrative of the Performance Testing discussing each element requiring testing, the tests performed, and the results. This test shall be performed when the plant systems are operational and there is water available for testing. Performance Testing is not complete until this report is submitted and approved by the Engineer. As part of the UV Performance Testing, power monitoring shall be conducted by the UV Equipment Supplier to indicate total power consumptions in kW-hr, power factors, and harmonic distortions at ballast's minimum, medium and maximum power settings.
   g. Harmonic testing results showing UV system performance measured at 50 percent, 75 percent and 100 percent of rated load with harmonics (Voltage and Current) measured to the 35^{th} harmonic. Results shall show that the harmonics are below IEEE 519 standards with a Point of Common Coupling (PCC) at the input terminals of the UV Local Control Panel.
   h. Power Factor tests results showing that the UV reactor maintain a 0.95 power factor throughout the full operating range.
3. Contract Closeout Submittals:
   a. Provide PLC and Operator Interface programs on CD in both Rockwell Automation software and PDF format.
      1) Fully documented ladder logic listings, function listing for function blocks not fully documented by ladder logic listings, cross-reference listings and operator interface configuration documentation.
   b. Service records for maintenance performed during construction.

1.05 AUTHORITY HAVING JURISDICTION APPROVAL

A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to State of Kentucky in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories (UL), Inc. shall conform to those standards and shall have an applied UL listing mark or label. Control panels shall also be UL 508 Labeled.

1.06 OPERATION AND MAINTENANCE DATA

A. Complete set of user manuals for all equipment, instruments and devices provided, including the programmable controllers.

B. List of spares and test equipment for the programmable controllers.

C. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 78 23, Operation and Maintenance Data.

1.07 WARRANTY

A. Equipment:

1. As part of the UV System shop drawing submittal, the Supplier shall furnish to the Owner an Equipment Warranty Certificate assuring that the UV System will meet the service conditions specified in this Section.
2. The Supplier warrants satisfactory performance of the equipment and UV lamp modules and ability of the UV System to achieve specified performance and water quality objectives.
3. If the UV System does not achieve the specified performance objectives, the Owner will notify the Supplier of the deficiencies in meeting the performance objectives. The Owner shall make available to the Supplier electronic records for review. The Supplier shall be given 15 days to develop a plan to correct the performance of the UV System.
4. Should the UV System fail to meet the required operating conditions after the necessary corrective measures are implemented, the Supplier shall forfeit the UV System Performance Bond and the Installation Contractor shall remove the system and replace it with one that will meet the project requirements and has been approved by the Owner. The Performance Warranty Testing detailed in this Section will not be performed until the UV System satisfies the Performance Testing requirements.

5. The equipment furnished under this section (excluding UV lamps and wiper rings) will be free of defects in materials and workmanship, including damages that may be incurred during shipping, storage and installation for a period of one (1) year from acceptance (completion of the performance / commissioning test). Defects shall be corrected by the Supplier at no additional cost to the Owner. The severity of the defect will determine the requirement of a site visit. All travel expenses accommodations etc. for a service visit due to a defect shall be included in the warranty with costs borne by the Supplier. Travel expenses for procedures classified as routine maintenance (i.e. lamp, sleeve, ballasts and sensor replacement) are not included under this warranty. If the performance guarantees are not met, the Supplier shall immediately, upon notice from the Engineer, make changes to the equipment to meet the performance guarantees at no cost to the Owner.
6. Engineering services and refresher trainings shall be furnished during the warranty period. The engineering services shall include two plant visits per year of at least 1 day's duration each (not including emergency visits, on a date agreed upon by the Owner) to check, furnish technical assistance, and provide calibration services for the equipment.

B. Guaranteed Parts Prices

1. Certification that the cost of replacement lamps, sleeves, wipers, ballasts, and sensors is guaranteed for a minimum period of 25 years from the date of acceptance after performance testing signed by an officer of the Supplier of the UV System. During the 25 years, the percent increase in prices shall not exceed the percent increase in the Consumer Price Index (CPI) published by the US Department of Labor, Bureau of Labor Statistics, applicable on the anniversary of the date of UV system acceptance.
2. The parts prices guaranteed for lamps, sleeves, wipers, ballasts, and UV intensity sensors shall not differ from the prices listed for those parts in the Bid Form for the life cycle analysis. The Supplier shall provide support documentation showing that the lamp and ballast prices of the Supplier's equipment are similar to, or lower than, prices charged to other Owners of the Supplier's equipment if applicable. Supply purchase orders or related documents supporting the quoted prices.

1.08 EXTRA MATERIALS

A. Spare Parts: Provide the following for the UV System:

1. UV Lamps: 10 percent of total of all lamps in all reactors, with minimum of four lamps.
2. Sleeves: 10 percent with minimum of two sleeves.

3. Ballasts: one unit.
4. Ballast Cooling Fan: One unit.
5. Duty UV Sensor: Two (2) per reactor.
6. Reference UV Sensor: Three (3) Sensors.
7. Cable/Conductor terminations 10 percent spare, of each type used with a minimum of 4, of each type used, of sufficient length to provide for four more cable runs.
8. Complete set of cleaning system wiper rings for one reactor.
9. Complete set of special tools to disassemble or adjust the UV System.
10. Complete set of O-rings seals for one reactor.
11. One year's supply of cleaning chemicals, (if applicable).
12. Spare parts for 1 year's operation of the UVT analyzer.
13. Spare parts for programmable controllers:
    a. One of each type rack power supply used.
    b. One of each type PLC processor used.
    c. One of each type of I/O module used.
    d. One of each type of mounting rack used
14. Three (3) pairs of eye protective goggles.

PART 2 PRODUCTS

2.01 UV SYSTEM MANUFACTURER (SUPPLIER)

A. The UV System Supplier shall be:

1. Trojan Technologies.
2. Calgon Carbon Corporation.
3. No substitutions or "or equal" will be allowed.

2.02 EQUIPMENT

A. Design Conditions:

1. The UV System shall be designed to provide a minimum of **2.5**-log inactivation of Giardia and Cryptosporidium at the full range of flows and water characteristics as described in the UV Data Table at the end of this Section.

2. UV Dose:
    a. Reactor must produce a Validated Dose equal to or greater than 8.5 mJ/cm^2. The calculated RED at the design conditions, with one reactor out of service, obtained using MS-2 bacteriophage must be greater than the product of 8.5 mJ/cm^2 and the validation factor (VF) calculated per the 2006 UVDGM.

b. The UV design dose shall be based on end of lamp life aging factor (ELAF) as provided by the UV Supplier based on the 3rd party verified lamp output as a fraction of specified new lamp output. The maximum ELAF shall be 0.90 and if no 3rd party certification is submitted the ELAF shall be 0.80. The quartz sleeve fouling factor (QSFF) for use in calculating the design dose shall be 0.90 (even if a different value is used in O&M calculations as described in Paragraph c below). Therefore, the fouling-aging factor equal to the product of the ELAF multiplied by 0.90 shall be used for system design to account for sleeve fouling, lamp aging and wear. If an alternate end of lamp aging factor is used, third-party certification (signed by a registered professional engineer) of the factor and the conditions under which it was determined shall be provided in the proposal.

c. For O&M calculations, UV Suppliers may use an alternate, third-party certified end of lamp life aging factor (ELAF) and quartz sleeve fouling factor (QSFF), if available for the proposed system. ELAF shall be in accordance with the guidelines described in paragraph b above. The maximum value for a 3rd party certified QSFF shall be 0.95. If no 3rd party certification is submitted for QSFF, 0.9 shall be used. If third party certified fouling or aging factors are used, the fouling-aging factor shall be the product of the UV System's third party certified end of lamp life factor and quartz sleeve fouling factor as shown on the Bid Form. If an alternate end of lamp aging factor or quartz sleeve fouling factor is used, third-party certification (signed by a registered professional engineer) of these factors and the conditions under which they were determined shall be provided in the proposal.

d. The UV Reactor validation shall confirm that the UV system, with one reactor out of service, is validated for all flow and UVT combinations within the following ranges:
   1) Flow: 10.0 to 44 mgd.
   2) UVT: 95 percent to 98 percent.

e. In addition, the UV Reactors shall be validated for a range of UVT that includes 85 percent UVT (Validated flow at 85 percent UVT may be less than the design capacity, and may be interpolated from validation greater than and less than 85 percent but not extrapolated).

3. UV System Redundancy: The UV system equipment shall be capable of 2.5-log Cryptosporidium disinfection at the design flow at the design dose with one UV reactor out of service.

4. The maximum design flow for each UV reactor shall be no less than 44 mgd at 95 percent UVT, dose for 2.5-log *Cryptosporidium* inactivation, and with fouled sleeves and at end of lamp life.

5. UV Reactor Headloss : Maximum of 15 inches measured from inlet to outlet flange.
6. Input Voltage: 480Vac plus or minus 10 percent.

B. All reactor components shall be designed to handle pressures of up to 50 psig and shall be fully assembled and hydrotested at 1.5 times the design pressure at the factory prior to shipment.

C. The UV System shall be comprised of the following components:

1. UV Reactors: three (2 online + 1 redundant) total.
2. Local Control Panel with an OIU: One per UV reactor.
3. UV System Master Control Panel with an OIU: one total
4. Number of UV Intensity sensor(s):
    a. Per 2006 UVDGM requirements.
    b. The system shall be able to continue providing disinfection while the UV intensity sensor is being calibrated or checked for calibration.
    c. One UV Intensity sensor per lamp.
5. Automatic Cleaning System: 1 per reactor.
    a. The system shall be able to continue providing disinfection while the automatic cleaning system is in operation.
6. UV Transmittance Monitor, capable of meeting performance requirements of UVDGM.

D. General:

1. Products that will be in contact with potable water shall have NSF 61 certification.
2. Equipment shall fully comply with OSHA standards.
3. Electrical material and equipment shall have UL listing or be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to State of Kentucky. Complete electrical assembly shall meet requirements of National Electrical Code (NEC), National Electrical Manufactures Association (NEMA), and National Fire Protection Association (NFPA) as well as having a UL 508 label.
4. Components, including equipment, coatings and other parts of system, shall comply with AWWA standards.

E. Terminal point connections shall be ANSI standard flanges.

2.03 UV SYSTEM SUPPLIER SCOPE OF SUPPLY

A. The UV System shall be furnished by the Supplier, complete with all validated UV reactors, power supplies, line filters, transient voltage surge suppressors, ballasts/transformers, lamps, quartz sleeves, calibrated duty and reference UV sensors (validated per the 2006 UVDGM), automatic cleaning system, cleaning chemicals, electrical interconnect wiring and control systems, UV transmittance monitor, water level and temperature sensors, for a complete and operable system.

B. UV Reactor:

1. General Requirements:
   a. Materials of Construction: The UV reactor shall be welded Type 316L stainless steel, pickled, passivated, and bead blasted for uniform external finish. Each reactor shall be supplied with 150-pound ANSI flanged inlet/outlet connections. All metal parts in the reactor shall be constructed of Type 316L, pickled and passivated stainless steel. All nonmetallic materials in the reactor shall be suitable for continuous exposure to UV light.
   b. Quartz sleeves shall be high purity, rated for maximum possible UV transmittance.
   c. Each lamp shall be enclosed in an individual quartz sleeve, sealed with compressed O-rings.
   d. Each quartz sleeve shall be independently sealed within the reactor.
   e. The UV reactor shall be designed such that operating personnel at the plant can change the lamps without draining the reactor.
   f. The UV reactor shall be provided with access ports for easy maintenance of the quartz sleeves, cleaning system, and sensor calibration and maintenance.
2. UV Lamps:
   a. The UV lamps shall be medium pressure (MP) .
   b. The filament shall be rugged to withstand shock and vibration.
   c. The lamp bases shall be resistant to UV.
   d. The lamps shall be operated by electronic or electromagnetic ballasts with multiple power settings ranging from at least 50 percent to 100 percent maximum power using at least 5 power steps as validated conditions.
   e. The UV lamps shall be guaranteed for a minimum number of operation hours. At the end of guaranteed lamp life, lamp output weighted for the germicidal emission spectrum (using a weighting equivalent to that used by the Supplier's intensity sensor), shall be greater than or equal to 80 percent of new lamp output, as measured in the field by the Owner using the system's UV intensity sensors. Thus, lamp life shall be determined by field tests based on intensity sensor readings. At the highest power setting, if the intensity reference sensor reading (or average of all reference sensors) for a clean lamp is less than or equal to 80 percent of the intensity sensor reading(s) for a new lamp, then

the end of lamp life shall be considered to have been achieved. If the Supplier submits an alternative ELAF, then the submitted value shall replace "80 percent" in the previous text.

3. UV Lamp Sleeves:
   a. The UV lamp sleeves shall be manufactured from General Electric Type 214, fully annealed clear fused quartz tubing, or equal.
   b. The open end(s) of the lamp sleeve shall be sealed by means of an O-ring and Type 316 stainless steel compression plate.
   c. The UV lamp sleeves shall be guaranteed for a number of operation hours. The guarantee shall be included on the Bid Form. At the end of guaranteed sleeve life, sleeve output shall be greater than or equal to 90 percent of new sleeve output.
4. Intensity Sensor(s):
   a. Only germidical sensors, as defined in the UVDGM, shall be allowed.
   b. A minimum of one sensor per MP lamp shall be provided. The variation in sensor readings within each reactor shall be validated and within the requirements of the 2006 UVDGM.
   c. Submittal for intensity sensors shall include details of sensor calibration and traceability, as well as information on uncertainty from linearity, temperature response, spectral response, angular response, and long-term drift, in compliance with the 2006 UVDGM.
   d. Include the sensor life and sensor calibration interval in compliance with the 2006 UVDGM. The sensor calibration interval shall be the time from installation into the operating facility until a sensor check versus a reference sensor requires sensor replacement.
   e. "Wet" Intensity Sensors shall not be used.
5. Cleaning System:
   a. Each UV reactor shall be equipped with an automatic quartz sleeve cleaning system.
   b. The cleaning system shall provide cleaning abilities for the lamp sleeves and UV sensor.
   c. Automatic cleaning systems shall be:
      1) Fully operational while still providing disinfection.
      2) Complete with an automatically initiated and controlled cleaning cycle.
      3) Field adjustable via the operator interface. Manual cleaning system control shall be available through the operator interface.
   d. The system shall be provided with the cleaning reagents and solutions required for initial equipment testing and equipment startup.
   e. Cleaning reagents and solutions used shall be NSF 60 approved.

6. Flow Conditioner Plate: provide flow conditioner plate at reactor entrance to match validation configuration.

C. Control Panels:

1. UV Reactor Local Control Panels (LCP):
   a. Power distribution and control for each UV reactor shall be through the associated LCP. The LCP shall house all power supplies and control hardware for the reactor.
   b. Each UV reactor LCP provided shall have a PLC and local OIU.
      1) The PLC shall be interconnected to the UV system master control panel PLC through the UV treatment facility Ethernet control network.
      2) The OIU shall communicate with the LCP PLC using Ethernet.
   c. Reactor to its Associated LCP Cables: Supplier shall supply the cables and terminator for connecting the UV reactor to its associated LCP. Cable shall be installed by the Installing Contractor in either PVC coated RGS conduit or liquid-tight flexible metallic conduit. Cable shall be rated for the proper power and temperature operating conditions. Cable length will be less than 70 feet per run (refer to Contract Drawings for UV equipment layout).
   d. The LCP shall include all control power transformers for all required voltages. The Supplier shall provide a complete power distribution system for the ballasts/lamps and ancillary equipment associated with each reactor. The electrical system shall comply with all requirements of NFPA 70, the National Electrical Code (NEC).
   e. The LCPs of each UV system will be powered through a dedicated 480-volt, or 480/277-volt, 3-phase isolation transformer (provided by others). The UV System Supplier shall include, if necessary, any harmonic filters to limit distortion (measured on the supply side of the isolation transformer) to 5 percent THD (current) and 5 percent THD (voltage) per IEEE 519 with the Point of Common Coupling being the LCP input power terminals.
   f. Disconnecting Means: each LCP shall be equipped with a main disconnect switch. This shall be interlocked with the door so that the door can not be opened with the disconnect switch in the closed or "ON" position, the disconnect switch shall also be capable of being padlocked in the OFF position. A circuit breaker shall be included for the main disconnect switch and ahead of each internal transformer, other circuit shall be fused per NEC

requirements. All breakers shall be fully rated, series rating is not acceptable. Available fault current shall be 30,000 amps symmetrical at 480 volts.

g. The LCP enclosure will be located indoors and shall be minimum NEMA 12, stainless steel. The room will be ventilated and kept lower than 80 degree F during summer.

2. UV System Master Control Panel (MCP):
   a. Control of the UV treatment system shall be provided through the MCP which shall be located adjacent to the individual LCPs. The following functions shall be provided through the MCP.
      1) UV reactor start/stop and power modulation.
      2) UV system communications to the Plant SCADA system.
   b. The MCP shall have a PLC and local OIU.
      1) The PLC shall be interconnected to the UV reactor LCP PLCs and the treatment facility PLC through the UV treatment facility Ethernet control network.
      2) The OIU shall communicate with the LCP PLC using Ethernet.
   c. Disconnecting Means: each MCP shall be equipped with a main disconnect switch. This shall be interlocked with the door so that the door can not be opened with the disconnect switch in the closed or "ON" position, the disconnect switch shall also be capable of being padlocked in the OFF position. A circuit breaker shall be included for the main disconnect switch and ahead of each internal transformer, other circuit shall be fused per NEC requirements.
   d. The MCP enclosure will be located indoors and shall be minimum NEMA 12, stainless steel.
3. Control Panel General Requirements (MCP and LCPs):
   a. Control wiring within each panel shall be segregated within the panel based on voltage. All voltages above 120V shall be separated by a solid metal barrier. Analog and dc wiring shall be kept separate from 120V ac and 480V ac wiring. Wiring shall be, minimum, No. 14 AWG for 120V ac control wiring and No. 16 AWG for analog wiring, minimum. In all cases, size wire for connected loads and include calculations for verification, showing appropriate derating, where needed. All wiring shall have an insulation rating of 600 volts.
   b. All panels shall be pre-wired to the maximum extent possible, requiring only field connections for power and field devices. For communication circuits, provide cable and connectors per device Supplier's recommendations. Provide measurements to certify that lead length limitations on communication circuit cabling have not been exceeded.

c. All control panels shall be provided with electrical safety interlocks, which prevent the panel from being opened when the main panel electrical disconnect is closed (providing power to the panel). Alternatively, an interlock may be provided to disconnect power from the panel when the door is opened. Safety interlock shall be Cutler-Hammer Flex Shaft, or equal.

d. Provided electrical safety interlocks shall be in full compliance with the NEC, applicable panel ratings (e.g., UL or approved by an NRTL-Nationally Recognized Testing Laboratory), local ordinances and requirements, and any additional plant safety rules.

D. Instrumentation and Controls - General:

1. The Supplier shall provide instrumentation and control for the UV System, which allows for the UV disinfection process to be fully automated and deliver the required UV dose under conditions of varying flow rates and varying UV transmittance. Transmittance signal shall be wired directly to the UV System Master Control Panel.
2. The Supplier shall make all program functions, I/O addresses and internal registers within their PLCs accessible by Owner's SCADA system. Coordinate all register units, ranges and conventions to facilitate data exchange.
3. Engineer shall be responsible for programming Owner SCADA system to provide supervisory control for all UV reactors, related valves, pumps, and instruments.
4. The Supplier shall provide the Owner with hard and electronic copies of the software installed in Supplier's PLCs, annotated to carefully detail all program instruction functions and purposes. Minimum control, monitoring and alarm signals/information are detailed in the Functional Requirements paragraph in this section.

E. Programmable Controllers:

1. UV control system (PLCs) shall be Allen-Bradley Control Logic processor, as specified below.
2. Communications: On-board Ethernet port for connection to the Plant SCADA system.
3. Power Supply Modules: As required.
4. Digital Input Modules: Provide isolated inputs.
5. Digital Output Modules: Provide relay outputs.
6. Analog Input Modules: Provide 4-20 mA, isolated.
7. Analog Output Modules: Provide 4-20 mA isolated.

F. Operator Interface Unit (OIU):

1. Panel-mounted graphical operator interface capable of bi-directional communication with PLC-based control system.
2. An OIU shall be mounted in each UV reactor local control panel and in the MCP.
3. Include all cables necessary to interface with the PLC control system and to a personal computer.
4. All OIUs shall be AB Panel View Plus 1000.

G. Functional Requirements:

1. The UV Control System shall calculate the UV dosage based on validated sensor set point or dose calculation. The UV reactor flow shall be provided to the LCP from the flow meter upstream of the UV reactor (installed by Contractor). The UV transmittance signal shall be provided by the UV transmittance analyzer. UV intensity sensors located within the UV reactor shall accurately sense any change in lamp power and compensate for any reduction in the UV-C output due to sleeve fouling and lamp aging. For emergency operation, an alternative manual control system shall be available which shall be based on assumed UVT and end of life power or user selected inputs.
2. The UV Control System shall monitor for equipment failure or malfunction and shall provide an alarm in response to such a failure.
3. The UV System MCP shall send a signal to the Plant SCADA with the maximum flow per reactor based on the current UVT and validated limits.
4. For plant startup, the Plant SCADA System shall provide a signal to the UV System MCP to start one or two UV reactors based on an operator entered flow set point during a plant start command and the maximum flow per reactor based on the signal from the MCP.
5. A permissive to start a UV reactor shall be a start command from the Plant SCADA and the position of the UV Reactor influent and cooling water drain valves. If the influent and cooling water drain valves for the reactor are in the OPEN position, the UV reactor shall be allowed to warm-up. The MCP shall determine which reactor(s) to start. An automatic rotation process shall be used.
    a. When a reactor start command is received, the UV system MCP will open the UV reactor cooling water drain valve prior to warming up the UV Reactor.
    b. Once the UV Reactor is ready, the UV system MCP will send a Reactor ready signal to the Plant SCADA system and the Plant SCADA system will open the UV Reactor isolation valve.

   c. The Plant SCADA system will send the UV System MCP the UV Reactor flow control valve position and the UV System MCP will close the cooling water drain valve on receipt of the UV Reactor flow control valve open signal.
   d. If the UV Reactor flow control valve fails to open with in an appropriate time as determined by the Supplier, the UV Reactor shall shutdown and the MCP shall cool the reactor down through the normal cool-down sequence.

6. During normal operation, the Plant SCADA system will monitor the plant flow and determine the number of UV reactors required based on the maximum flow at the current UVT. If a second UV reactor is required, the Plant SCADA system will request an additional UV reactor from the MCP.
   a. When a reactor start command is received, the UV system MCP will open the UV reactor cooling water drain valve prior to warming up the UV Reactor.
   b. Once the UV Reactor is ready (warmed up), the UV system MCP will send a Reactor ready signal to the Plant SCADA system and the Plant SCADA system will open the UV Reactor isolation valve.
   c. The Plant SCADA system will send the UV System MCP the UV Reactor flow control valve position and the UV System MCP will close the cooling water drain valve on receipt of the UV Reactor flow control valve open signal.
7. If two UV reactors are on-line and the plant flow drops so that only one reactor is needed, one reactor will be taken off-line.
   a. The UV System MCP will send the UV Reactor minimum validated flow at the current UVT to the Plant SCADA System.
   b. If the UV Reactor Flow drops below 125% of the minimum validated flow at the current UVT, the Plant SCADA System will close the UV Reactor flow control valve.
   c. Upon receipt of a UV reactor flow control valve closed signal, the UV System MCP will open UV Reactor cooling water drain valve and begin the UV Reactor cool-down period.
   d. At the completion of the UV Reactor cool-down period the UV System MCP will close the UV Reactor cooling water drain valve.
8. One reactor shall be in standby when the plant production rate reaches a defined set point.
9. Control and monitoring of the valves, pumps, and other devices external to the UV LCPs will be provided by the Contractor. UV supplier shall coordinate details of external interfacing and communications with them.

10. As a minimum, the UV Control System shall provide the following process monitoring and status information to the Plant Control System:
    a. Status of the UV Reactor: OFF, Warming Up, Ready (no flow), ON (water flowing), and Cooling Down.
    b. Cumulative number of ON/OFF cycles for the UV lamps.
    c. Run time for each lamp.
    d. ON/OFF status for each lamp.
    e. Reactor power setting.
    f. System Ready: UV Reactor is ready to operate and no faults or unusual conditions exist.
    g. UV dosage.
    h. UV transmittance.
    i. Power draw.
11. As a minimum, the UV Control System shall provide the following alarms to the Plant SCADA System:
    a. Lamp failure.
    b. Ballast failure.
    c. Lamp run time hours exceeded.
    d. Multiple lamp failure.
    e. Multiple ballast failure.
    f. Ballast high temperature.
    g. Lamp calibration check required.
    h. High chamber/lamp temperature.
    i. Low UV intensity.
    j. GFI breaker trip.
    k. Low reactor water level.
    l. Low UV calculated dose.
    m. Cabinet high temperature.
    n. Dose communication time out.
    o. UV sensor signal loss.
    p. UV sensor signal saturated.
    q. Calibrate UV sensor.
    r. Loss of UVT signal.
    s. Lamp start-up failure.
    t. High/Low flow rate.
    u. SCADA communication fail.
    v. Control panel emergency stop.
    w. Wiper jam/fault.
12. The UV Control System shall receive the following commands from the Plant SCADA System:
    a. UV reactor required to be put IN-SERVICE.
    b. Fault RESET.
    c. UV reactor remote ON/OFF.
    d. Influent valve OPEN/CLOSED.
    e. UV Reactor effluent valve position.

13. The UV Control System shall receive the following process monitoring information from the Plant SCADA System:
    a. UV reactor flow.

H. Field Instruments:

1. UV Transmittance Analyzer:
    a. Provide a continuous reading, flow-through UV transmittance spectrophotometer suitable for measurement of UV transmittance of the GAC effluent water. The unit shall be self-contained and shall include sensor and analyzer. The sensor shall consist of a UV light source, filter, sample cell, and detector.
    b. The analyzer shall be suitable for a 120V ac power supply and housed in a NEMA 4X enclosure.
    c. The analyzer shall comply with the accuracy, uncertainty, and reliability requirements defined in the 2006 UVDGM.

I. Other: Refer to Part 1 and Part 3 of this Section for additional items to be furnished by the UV system Supplier.

2.04 SCOPE OF SUPPLY FOR INSTALLING CONTRACTOR

A. The Contractor ("Installing Contractor") shall be responsible for supplying and installing all the necessary materials, equipment and appurtenances not supplied as part of the scope of supply for the UV System Supplier, but required for a complete, functional and operational UV System. Including, but not limited to:

1. Supports required to install the UV reactors that are not supplied by the UV System Supplier (supports not directly connected to the UV Reactors, i.e. pipe supports for upstream and downstream piping whether it supports the UV reactor or not. All structural calculations shall meet the requirements of the local building code, be reviewed by the UV System Supplier and be signed by a registered Professional Engineer in the State of Kentucky with a Structural or Civil discipline.
2. All the hardware, fasteners, anchor bolts, nuts, plates and angles necessary for the installation of the UV System. All hardware, fasteners, anchor bolts, nuts, plates, angles, etc. shall be Type 316 stainless steel.
3. All mating flanges, insulating flanges, couplings, gaskets, bolts, nuts, and all necessary piping specialties to install the reactors, and analyzers, supplied by the UV System Supplier. Mating flanges shall be as required in the pipe schedule. All bolts, nuts shall be Type 316 stainless steel. Gaskets shall be EPDM.

4. All conduit, fittings, supports, hubs and wiring including wire terminations and terminators necessary for the complete installation of the UV reactors, LCPs, instruments, analyzers, devices and OUIs supplied as part of the UV System.
5. All the equipment supports, u-bolts, and all necessary hardware to install all the ancillary equipment supplied by the UV System Supplier. Ancillary equipment shall include UVT analyzers, control and power panels, and other equipment needed for a fully functional and validated UV system.
6. Provide on-site assistance to UV System Supplier during Functional Testing as defined in the Functional Test Procedures developed by the UV System Supplier and approved by the Engineer.
7. Provide on-site assistance to UV System Supplier during Performance Testing as defined in the Performance Test Procedures developed by the UV System Supplier and approved by the Engineer.

B. Installing Contractor shall refer to the UV Supplier's Submittal's for additional requirements.

2.05 WORKSHOPS AND MEETINGS

A. UV Supplier and Installing Contractor shall attend a 2-day coordination meeting specified below at the Owner's facility, prior to start of programming.

1. Supplier shall coordinate with the Contractor, Engineer and Owner for the configuration and programming of the SCADA .
    a. Supplier shall attend a SCADA development workshop at the Owner's facility to create preliminary sketches (developed by Contractor) for all displays that will be developed for the project. This workshop shall include:
        1) Overview display design.
        2) Process graphics.
        3) Display paging and navigation.
        4) Equipment control features; pop-up windows.
        5) Data entry through OIU.
        6) Coordination issues with plant-wide SCADA.
        7) Color conventions and symbols in compliance with Owner's standard.
        8) Define all Alarms and security setup.
        9) Portability of database and graphics into plant-wide SCADA i.e., ensure no conflicts in databases.
        10) Memory mapping between local PLCs, OIUs and plant-wide SCADA.

2. Provide recommended overview display graphic. This can be in the form of a sketch or typical graphic and should convey to Contractor and Owner what information is important to display and monitor concerning system operation.
3. Provide recommended detail display graphics (if any). Sample graphics may include more detailed monitoring screens, data displays, increased process or equipment detail vs. the overview graphic, etc. Information is expected to be in the form of a sketch or typical graphic display, similar to above.
4. Provide memory mapping to clearly identify all registers to be used for external monitoring and control with a detailed description of the meaning and function of each register, including values expected, minimum and maximum values, engineering units of value, etc. For Boolean registers, clearly define the meaning of each state.
5. Provide recommended list of points and values to alarm, including recommended alarm set points on analog values.
6. It is the responsibility of the Contractor to schedule the above workshops with the Owner in a timely manner. The Contractor must also include the participation of the Engineer in the above workshops.

2.06 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel, with 1/4-inch engraved block type black enamel filled equipment identification number and letters shown in the Contract Drawings. Mount securely in a readily visible location. Identification Plates shall be supplied and installed by the Installing Contractor. Identification Plates shall be provided for all reactors and control panels.

B. Space Heaters: Thermostatically controlled. Locate in each panel, for operation from 120-volt power source derived internal to LCP.

C. Lifting Lugs: For equipment weighing over 100 pounds.

D. Anchor bolts shall be Type 316 stainless steel, supplied and installed by the Installing Contractor.

2.07 GUARANTEED PERFORMANCE REQUIREMENTS:

A. Disinfection

1. The UV System shall deliver the design UV dose or a higher dose at the design UV transmittance under peak flow rate conditions with one reactor out of service under the water quality conditions identified and taking into account the Combined Derating Factor for EOLL and fouled condition.

B. Lamp Life:

1. The lamp life shall be defined as the number of operating hours before the UV output of each UV lamp drops to 80 percent of the benchmarked 100-hour output at maximum input power.

C. Power Consumption:

1. The peak system power consumption, calculated as the sum of measurements at the energy monitoring unit (EMU) of each CPP, shall not exceed the guaranteed total UV System power submitted by the Supplier in the Bid Form. The peak power consumption shall be the product of the measured power consumption per lamp (including ballast losses) and the total number of the installed lamps plus any power requirement of all accessory equipment including, but not limited to, control system, fans, cooling, and motors.

D. Ballast Life:

1. Ballasts shall be fully warranted for the ballast warranty period included in the Bid Form on at least a pro-rata basis, and shall be designed for a 10 year minimum life span.

E. Harmonic Distortion:

1. Maximum total voltage harmonic distortion (THD) of the UV System shall not exceed 5 percent as set forth in IEEE 519-1992, Table 10.2, at the point of common connection. For this system, the point of common connection shall be the associated 480 volt bus on the UV distribution switchboard. THD shall be determined by appropriate sections and requirements of IEEE 519-1992. The Supplier shall be responsible for providing and installing all harmonic mitigation equipment including active or passive filters, isolation transformers, conduit, wire, filter control interlocks, etc. as required to meet the harmonic limitations as specified herein at no additional cost to Owner.

2.08 SOURCE QUALITY CONTROL

A. All UV System equipment and unit specific controls shall be factory tested at the Supplier's testing facility before shipping. Factory testing must be approved by the Engineer before shipping.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installing Contractor shall install products in conformance with UV System Supplier's shop drawings and installation instructions.

B. Installing Contractor shall energize all space heaters as soon as the equipment arrives on site.

C. Installing Contractor shall provide all interconnecting structures, equipment, piping, electrical and instrumentation work, finish painting, and appurtenances as shown on the Drawings and UV System Supplier's approved drawings, to achieve a complete and functional system.

D. Installing Contractor shall provide foundation pads for products as shown. Verify exact dimensions and configuration of all pads, including penetrations, with UV System Supplier's furnished product shop drawings.

E. Anchor Bolts:

1. Where required, Installing Contractor shall provide anchor bolts, fasteners, washers, and templates needed for installation of UV Equipment.
2. Size and locate anchor bolts in accordance with UV System Supplier's product shop drawings, calculations and installation instructions.

F. Installing Contractor shall properly align, plumb and level, with no stresses on connecting piping or conduit all mechanical and electrical equipment.

G. Installing Contractor shall verify operability and safety of electrical system needed to operate equipment. Check electrical system for continuity, phasing, grounding, and proper functions.

3.02 TESTING

A. The UV System Supplier shall be required to complete several required tests. These tests shall include:

1. Factory Test.
2. Functional Test.
3. Performance Test.

B. Factory Test:

1. The UV System Supplier shall be responsible for the Factory Test that shall be conducted by the UV System Supplier, after the shop drawings are approved and before system is shipped to the site.

2. The UV System Supplier shall factory test all major system components of the UV System during a single test session for compliance with the construction and functional requirements specified herein.
3. The UV System Supplier shall submit a Factory Test Plan, for approval, to the Engineer that will demonstrate the full operability of UV Reactors. The test plan shall include, but is not limited to the testing of the delivery of the UV dosage, the lamps, the intensity sensors, the cleaning system, local control panel for each of the reactors, and the instrumentation and controls for each of the reactors, and operator interface units. The scope of the Factory Test shall demonstrate that each individual component of the UV System operates as specified.
4. After approval of the Factory Test Plan by the Engineer and Owner, the testing shall be performed and may be witnessed by the Engineer and Owner at the UV System Supplier's testing facility. Engineer and Owner's travel expenses to factory testing will be at Owner's expense.
5. The UV System Supplier shall submit a Factory Test Report discussing the tests performed, items witnessed, and the results for the approval of the Engineer and Owner upon conclusion of the Factory Test.
6. The UV System shall not be shipped until the Factory Test Report is approved.

C. Functional Testing:

1. The first on-site element of the required testing shall consist of Functional Testing for all UV reactors. For the Functional Testing, the Installing Contractor and the UV System Supplier shall verify operation of all system components, all control system functions, all system alarms, and communication links. The Functional Testing shall also include verifying the operation of the control system for local and remote operation. The lamp output shall be changed to verify that the sensor outputs are sufficiently sensitive to pick up the decrease in UV intensity. Functional testing shall demonstrate impacts of loss of UV transmittance signal, UV intensity signal, and flow rate signal. In addition the accuracy of the reference sensors shall be checked against the other reference sensors, and each duty sensor will be checked against a reference sensor. Any sensor not in compliance with UVDGM requirements shall be replaced.
2. The UV System Supplier shall inspect the installed UV System for proper alignment, proper equipment supports, correct operation, proper connection, and satisfactory function of all components. All signals shall be verified, and all alarms shall be tested.
3. Functional testing shall be performed in coordination with the Contractor. UV System Supplier shall test each control signal required to be communicated between the UV control system and the plant SCADA system for proper operation.

4. The UV System Supplier shall approve the installation and provide written certification that the system components have been installed properly, and are ready for operation. The Installing Contractor shall notify the Engineer and Owner of Functional Testing schedule to allow the Engineer and Owner to witness testing.
5. The Installing Contractor shall ensure all ancillary systems (valves, control system, etc.) required for Functional Testing are available for use.
6. UV System Supplier shall coordinate with Contractor for control system operation during functional test and shall lead the testing.
7. The proposed Functional Testing procedure shall be developed by the UV System Supplier, submitted to the Engineer and Owner, and reviewed by the Owner and Engineer before scheduling and performing Functional Testing. In the case of a nonconforming system, as determined by the Engineer and Owner, advancement to Performance Testing shall not commence until the UV System Supplier has made, at no additional cost to the Owner or Installing Contractor, such adjustments and modifications as are necessary to correct the system, and has demonstrated this by repeating the Functional Testing until satisfactory.
8. The UV System Supplier shall prepare a Functional Testing Report and shall submit two electronic and two hard copies of the report to the Engineer within 14 days of completion of the Functional Testing.
9. Both the UV System Supplier and the Contractor shall be onsite for the duration of the Functional Testing.

D. Performance Testing Basic Requirements:

1. The Performance Testing shall include head loss tests, power consumption tests, UVT and intensity sensor calibration checks, power factor measurements, UV System dose (based on UV System control panel readings and calculations), and operation in auto mode. The UV System Supplier shall develop performance test procedures, which shall be approved by the Engineer prior to testing. The Performance Testing shall proceed for a minimum of 3 days continuous operation.
2. Performance testing shall verify system operation without malfunction for a period of 3 continuous days. Any malfunction during this period shall be addressed and the 3-day test shall be restarted until full system performance is approved by the Owner and Engineer.
3. Performance testing shall be completed on all UV reactors. The system must operate for all 3 days, but individual reactors may go in and out of service as needed. The system will be challenged to verify correct operation (i.e., reactor failure or loss of UVT signal).
4. No off-specification operations shall be allowed during the 3-day Performance Test.

5. The test will be conducted by the UV System Supplier and Installing Contractor under the observation of the Engineer. The Owner may obtain the services of an independent consultant or testing laboratory to observe and verify procedures and test results at the option and cost of the Owner.
6. Owner will provide power and process water required to operate the system during the performance test.
7. At least 30 days prior to the proposed testing date, Contractor shall notify the Engineer and UV System Supplier of the testing date and shall submit a report from the UV System Supplier detailing the proposed performance testing equipment and schedule. This submission shall include the following:
   a. Instruments to be used for measurements.
   b. Relative precision of the instruments, and methods of calibration.
   c. Data sheets for recording measurements.
   d. Procedures for making calculations, including example calculations.
   e. Procedures for documenting compliance.
8. UV System Supplier shall provide all instruments and other supplies necessary for conducting the tests.
9. UV System Supplier shall collect all data and compile the performance test results, including the calibration data, and submit four copies of the report to the Engineer. Within 14 days after completion of the performance test, two hard copies and two electronic copies of the raw data shall be provided to the Engineer.
10. UV System Supplier shall use portable, factory calibrated kilowatt hour meters with accuracy of 0.25 percent of reading. Factory calibration reports shall be provided to the Engineer for all power meters not less than 10 days prior to the scheduled performance tests.
11. The flow and water temperature shall be measured with the installed Water Treatment Plant instruments. These instruments shall be calibrated, but readings will not be corrected to account for errors inherent in the equipment. Direct readings will be used.
12. Except as specifically required, herein, the system shall be operated during the performance tests as intended for normal, long-term operation under the conditions specified.
13. UV System Supplier and Installing Contractor shall observe the requirements of the Operation and Maintenance Manual, the Plant Safety and OSHA rules at all times.
14. The power draw and power factor of the system shall include all reactors, sensors, control panels, and other appurtenances.
15. Power draw shall be measured for each reactor individually and shall be based on each individual reading.
16. Perform sensor calibration checks of duty and reference sensors and provide uncertainty calculations based on field evaluations. Compare

sensor uncertainty based on field evaluations with that provided in the third-party validation report and compliance with the 2006 UVDGM requirements.

17. Perform UVT monitor calibrations and reading stability checks, with the use of the Owner's laboratory spectrophotometer, and prepare documentation on its compliance with the 2006 UVDGM requirements.
18. Both the UV System Supplier and the Installing Contractor shall be onsite for the duration of the Performance Testing.
19. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
    a. Total and individual current harmonic distortion (up to and including 35th harmonic) at location identified as PCC, under the following load conditions:
        1) UV reactors operating at full load and half load.
        2) Half of the specified UV Reactors operating at full load and half load.
    b. Power factor at input side of each UV Reactor. Documented verification that power factor is maintained at 95 percent as power setting goes down from 100 percent to 50 percent.
    c. Test Equipment: Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
20. With plant load connected to standby power source, measure the following to show parameters within specified limits:
    a. Total and individual current harmonic distortion (up to and including 35th harmonic) at location identified as: PCC, with UV Reactors running at:
        1) Full load.
        2) Half load.
    b. Test Equipment: Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.

E. Performance Testing, Supplemental Requirements:

1. Power Consumption: Power consumption shall be measured at each energy monitoring unit (EMU) for the 3-phase feeder entering the CPP. Power measurements shall be taken when all lamps are needed to meet the design criteria with all trains in service. Kilowatt-hours and power factor shall be measured and recorded. The meter shall have been calibrated immediately preceding this test.
2. A qualified representative of the Supplier shall supervise the Performance Testing with assistance from the Installation Contractor as required, and shall certify the UV System's performance during the tests. Tests shall be documented during continuous operation of the system, and the Supplier shall submit to the Engineer three copies of a

complete report containing all original test data, calculations, and descriptions of the Performance Testing procedures and results.

3. During performance testing, the following will be observed and recorded:
   a. Lamp status (on/off)
   b. Verification of system operation within validated limits of flow rate and UV Transmittance
   c. Measured UV irradiance (sensor output) over time
   d. Verification of on-line sensor operation with reference sensors
   e. Ballast temperature and cooling system performance
   f. Monitor fouling and impact on system performance, if any
   g. Electrical service, voltage, current, and power consumption
   h. Monitoring system operation
   i. Alarm system operation
   j. Monitoring flow rate
   k. Flow distribution between UV reactor trains
   l. Lead / lag operation
   m. Control of system operation including variable intensity operation
   n. Download of operational data
   o. Interfacing with the plant SCADA system
4. If, in the opinion of the Engineer, the system meets the performance requirements during the Performance Testing, the Engineer will recommend to the Installation Contractor and the Owner, by letter, the official acceptance of the UV System. If, in the opinion of the Engineer, the Performance Test results do not meet the requirements specified herein, the Engineer will notify the Supplier and the Owner in writing of the unacceptable performance.
5. In the case of unacceptable performance, the Supplier shall then have 60 days in which to perform, at the Supplier's sole expense, any supplemental testing, equipment adjustments, changes or additions and request an additional retest of the unacceptable system.
6. Should the UV System fail to meet the required operating conditions after the necessary corrective measures are implemented, the Supplier shall forfeit the UV System Performance Bond and the Installation Contractor shall remove the system and replace it with one that will meet the project requirements and has been approved by the Owner. The Performance Warranty Testing detailed below will not be performed until the UV System satisfies the Performance Testing requirements.
7. Final completion of the project will not be certified until successful completion of this work.

F. Performance Warranty Testing

1. Performance Warranty Testing will consist of Lamp Output and Lamp / Component Replacement Tests. These tests shall begin upon commencement of the project warranty period. The Supplier's

representative shall assist the Owner with testing as directed, for a minimum of one day per month. During the Performance Warranty Testing period, the Supplier and the Installation Contractor shall have access to the Project to observe Project operations and testing procedures, and shall also have access to all test data when available. The Supplier and Installation Contractor shall immediately notify the Owner in writing of any irregularities, discrepancies or deviations in Project operation, maintenance, test procedures or test results.

2. The Supplier and Installation Contractor failure to exercise their right under this Paragraph to observe the Performance Warranty Testing and to provide written notices to the Owner during the warranty period shall constitute a waiver by the Supplier and Installation Contractor of any objection to the Owner's test procedures, data gathering methods, data, or operation and maintenance of the Project during the warranty period.

3.03 TRAINING

A. UV System Supplier shall provide a minimum of the following training classes to the Owner at the Owner's project site (note the times stated below exclude travel time):

1. 4 person-days (24 hours) of operational training.
2. 2 person-days (12 hours) of maintenance training.
3. 6 days of Owner support through 6 trips in the first 12 months of operation. Support shall be provided at Owner's request.

B. UV System Supplier shall provide the Owner with written training course outlines 1 month before the first training session. Owner shall be able to comment on course material, and UV System Supplier shall revise as requested.

C. Training times shall be as determined by Owner. Session schedules shall be adjusted to account for interruptions in operability of equipment.

D. The Owner may choose have the training sessions video recorded at the owner's discretion and expense. Training sessions shall be video recorded per Section 01 43 33, Manufacturers' Field Services.

E. Training shall comply with Section 01 43 33, Manufacturers' Field Services, except as modified in this Section.

3.04 INSTALLATION ASSISTANCE AND TESTING

A. All times stated below exclude travel time.

B. UV System Supplier shall provide a minimum of 2 days unloading and equipment inspection upon UV System arrival onsite.

C. UV System Supplier shall provide a minimum of 8 days in 4separate trips (2-day trips) for installation assistance to the Installing Contractor. The UV System Supplier shall coordinate the site visits with the Installing Contractor. UV System Supplier shall provide a Manufacturer's Certificate of Proper Installation.

D. UV System Supplier shall provide a minimum of 6 days in two separate trips (3-day trips) for Functional and Performance Testing. The UV System Supplier shall coordinate the site visits with the Installing Contractor and Owner.

E. Supplier shall provide an anticipated maximum of 60 hours of remote engineering support to the Owner and Engineer.

F. Owner will approve schedule for all trips.

3.05 PERFORMANCE WARRANTY AND LIQUIDATED DAMAGES FOR BREACH OF PERFORMANCE WARRANTY

A. In addition to other warranties provided, the UV System Supplier shall warrant the power consumption and component / lamp replacement frequency of the UV System as provided in this Paragraph. The warranties provided in this Paragraph are cumulative and do not supersede any warranties provided elsewhere in the Contract Documents.

1. The Supplier shall warrant for a period of one year that UV System will achieve the disinfection requirements specified in this Section without exceeding the Guaranteed Total UV System Power Consumption set forth by the Supplier in the Bid Form. The one-year warranty period will not begin to run until the successful completion of all testing required by the Contract Documents and the issuance by the Owner of the Notice of Completion for the UV System. If the UV System consumes more power than warranted, the Supplier will be assessed liquidated damages pursuant to this Section.
2. The Supplier shall warrant for a period of one year that the UV System will achieve the disinfection requirements specified in this section without exceeding the warranted frequency of component/lamp replacement for the UV System provided by the Supplier in the Bid Form. The warranty period for the UV lamps, ballasts and intensity monitors shall begin on the date the UV System is put into beneficial use by the Owner regardless of flow condition. If the UV System component/lamp replacement frequency is greater than warranted, the Supplier will be assessed liquidated damages pursuant to this Section.

B. The component / lamp warranty shall consist of two parts: (1) a full replacement warranty period, and (2) a pro-rata warranty period. The component / lamp warranty period shall be the period established in the Bid Form.

1. The full replacement warranty period shall last for a period of at least 1,000 hours after the date of installation as described below:
    a. For UV component / lamps supplied as part of the original equipment installation, the date of installation is when the system is available for beneficial use (after successful completion of Performance Testing).
    b. For UV components / lamps provided after the system is available for beneficial use (after successful completion of Performance Testing), the full replacement warranty period begins the date of initial UV component / lamp installation.
    c. The Owner shall record and maintain records of the date of installation for UV components / lamps.
2. The pro-rata warranty period shall commence with the end of the full replacement period and last until the end of the pro-rata warranty period as submitted by the Supplier in the Bid Form for the UV System.
3. The Supplier warrants that the UV components / lamps will be free from defects in:
    a. Materials.
    b. Workmanship.
4. If the UV component / lamps fail to perform during the warranty period as outlined in the service conditions specified in this Section, the Supplier will be given the opportunity to remedy the situation by modifying operating protocols or by replacing the components / lamps.
5. Should the UV System fail to meet the required operating conditions after the necessary corrective measures are implemented, the Supplier shall forfeit the UV System Performance Bond and the Installation Contractor shall remove the system and replace it with one that will meet the project requirements and has been approved by the Owner. The Performance Warranty Testing detailed in this Section will not be performed until the UV System satisfies the Performance Testing requirements.
6. Limitation of Warranty: Owner recognizes that the occurrence of any of the following shall void the UV component / lamp warranty.
    a. Physical Damage or Faulty Installation of the UV lamps by others.
    b. Unauthorized alteration of components manufactured by the Supplier.
    c. Use of cleaning procedures other than procedures approved by the Supplier.
    d. The Supplier warrants that the UV components / lamps are suitable for use in the treated surface water.

e. The Supplier is responsible for the identification of water quality parameters, instrumentation and PLC programming required to satisfy and maintain UV lamp warranty provisions. The Supplier shall establish the instrumentation alarm limits that would result in the operation of the equipment outside of Supplier established limits.

f. Improper maintenance of equipment.

g. Failure of the Owner to maintain electronic operational logs as required by the Supplier. The Owner will not be responsible for the maintenance of manual (handwritten) operational logs. The maintenance of electronic logs is subject to the following conditions:

   1) The Supplier is responsible to provide to the Owner a listing of the operational data points that are to be electronically logged.
   2) The Supplier is responsible for the PLC programming of data points that are to be electronically logged.
   3) The Supplier shall identify minimum frequencies of logging of all operational data points required by the Supplier to maintain UV component / lamp warranty provisions.
   4) The Supplier shall establish the alarms limits that would result in the operation of the equipment outside of Supplier established limits.
   5) The Supplier shall be solely responsible for the identification and programming of system interlocks that would result in the operation of the system outside of the parameters required by the Supplier. The Owner will not be responsible for errors in Supplier developed programming that would result in operation of the system outside of the Supplier established limits.

h. In the event of a warranty claim, failure of the Owner to provide the Supplier with electronically logged operational parameters.

7. Changes in the Supplier established operational and maintenance guidelines shall not be applied retroactively to invalidate the warranty.

8. UV Component / Lamp Replacement Costs:

   a. The Supplier shall establish the initial UV component / lamp replacement prices in the Bid Form and guarantee that the respective UV components / lamp replacement prices shall not increase by more than the prevailing Consumer Price Index (CPI) over a twenty-five (25) year period.
   b. During the full replacement warranty period, the Supplier shall provide replacement component / lamps at no cost to the Owner.

c. Component / Lamp Replacement Price during the pro-rata warranty period shall be calculated as follows:

$$\text{Pro Rata Replacement Price} = \frac{\text{Replacement Price x Hours of Beneficial Use}}{\text{Component / Lamp Replacement Warranty Period (Hours)}}$$

1) The pro-rata component / lamp life will be capped at the warranted life entered in the Bid Form.

9. Definition of Component / Lamp Failure.
   a. UV lamps shall be deemed to have failed when they:
      1) Fail to light when struck.
      2) Fail to achieve performance requirements for disinfection.
      3) UV intensity falls below 80 percent of initial lamp output (with initial lamp output measured after a 100-hour burn-in period).
   b. UV ballasts shall be deemed to have failed when they:
      1) Fail to properly operate UV lamps.
   c. UV intensity monitors shall be deemed to have failed when they:
      1) Are not able to be calibrated properly at the factory.
      2) Drift out of calibration more than twice per year when checked with the reference intensity sensor per USEPA guidelines.
10. The Supplier shall ensure disposal of returned lamps (old/used) at no costs to the Owner upon receipt of the returned lamps at the manufacturing headquarters. Shipping costs however shall be borne by the Owner.

C. The Owner and the Supplier agree that, in the event the UV System does not perform as warranted with regard to power consumption and lamp / component replacement frequency, the Owner will suffer damages over the course of the useful life of the Project, but that such damages will be extremely difficult or impossible to measure. Therefore, the Owner, the Installation Contractor, and the Supplier agree that the Owner's damages in the event the UV System does not perform as warranted with regard to power consumption and lamp, sleeve, wiper, ballast, and intensity sensor replacement will be liquidated and calculated as provided in this Paragraph and paid by the Supplier to the Owner.

D. Liquidated Damages for Breach of Performance Warranty

1. Liquidated damages for breach of the Supplier's performance warranty for the UV System will be based on the present worth of the difference between the total excess measured power consumption and lamp replacement and the figures warranted by the Supplier.

2. Liquidated damages for excess power consumption shall be calculated as shown in Equations No. 1 through No. 6 below. Equations are provided for the following:

   a. Equation No. 1 Guaranteed Total UV System Power.
   b. Equation No. 2 Annual Total UV System Power Consumption.
   c. Equation No. 3 Prorated Annual Power Consumption.
   d. Equation No. 4 Excess Annual Power Consumption.
   e. Equation No. 5 Excess Annual Power Consumption Cost.
   f. Equation No. 6 Liquidated Damages for Excess Annual Power Consumption.
3. The items referenced in the equations are from the Bid Form. Present Worth Costs are based on the values presented in the Bid Form. The liquidated damages for excess power consumption represent the additional electrical costs that the Owner will incur to operate the UV System.
4. Liquidated damages for excess component/lamp replacement shall be calculated as shown in Equations No. 7 through No. 12 below. Equations are provided for the following:
   a. Equation No. 7 Measured Number of Component/Lamps Replaced.
   b. Equation No. 8 Guaranteed Annual Component/Lamp Replacement.
   c. Equation No. 9 Prorated Annual Component/Lamp Replacement.
   d. Equation No. 10 Excess Annual Component/Lamp Replacement.
   e. Equation No. 11 Excess Annual Component/Lamp Replacement Cost.
   f. Equation No. 12 Liquidated Damages for Excess Annual Component/Lamp Replacement.
5. Liquidated damages shall be limited to the total Proposal amount as listed in the Bid Form.

5. Liquidated Damages for Breach of Performance Warranty
Power Consumption Worksheet

Equation No. 1 Measured Power Consumption

Measured Power Consumption (kW) = Measured Power Consumption at the UV System Submeter

Equation No. 2 Guaranteed Annual Power Consumption

Guaranteed Annual Power Consumption = Annual Power Consumption(kWhr/yr)

Equation No. 3 Prorated Annual Power Consumption

Prorated Annual Power Consumption (kWhr/yr) = [Measured Power Consumption (Equation No. 1) x 8,766 hrs/yr] / Actual Operating Hours

(Where the Actual Operating Hours = Actual hours operated during the measurement of power consumption)

Equation No. 4 Excess Annual Power Consumption

Excess Annual Power Consumption (kWhr/yr) = Prorated Annual Power Consumption (Equation No. 3) – Guaranteed Annual Power Consumption (Equation 2)

(Note: liquidated damages apply if the Excess Annual Power Consumption > 0)

Equation No. 5 Excess Annual Power Consumption Cost

Excess Annual Power Consumption Cost ($) = Excess Annual Power Consumption (Equation No. 4) x Cost of Power

Equation No. 6 Liquidated Damages for Excess Annual Power Consumption

Liquidated Damages for Annual Power Consumption Cost ($) = Excess Annual Power (Equation No. 5) x Present Excess Worth Factor

6. Liquidated Damages for Breach of Performance Warranty
Component/Lamp (Parts) Worksheet
Components or Parts include: Lamps, Sleeves, Wiper, Ballasts, and Intensity Monitors

Equation 7 Measured Number of Parts Replaced

Measured Part Replacement (parts/time) = Total Number of Parts Replaced during the Performance Warranty Period

Equation 8 Guaranteed Annual Part Replacement

Guaranteed Annual Part Replacement (parts/yr) = Total Number of Duty Parts x 8,766 hrs/yr / Guaranteed Part Life

Equation 9 Prorated Annual Part Replacement

Prorated Annual Part Replacement (parts) = Measured Part Replacement x 8,766 hrs/yr / Actual Operating Hours

(Where the Actual Operating Hours = Actual hours operated during the Performance Warranty Period)

Equation 10 Excess Annual Part Replacement

Excess Annual Part Replacement (parts) = Prorated Annual Part Replacement (Equation 9) – Guaranteed Annual Part Replacement (Equation 8)

(Note: liquidated damages apply if the Excess Annual Part Replacement > 0)

Equation 11 Excess Annual Part Replacement Cost

Excess Annual Part Replacement Cost ($) = Excess Annual Part Replacement (Equation 10) x Cost per Part

Equation 12 Liquidated Damages for Excess Annual Part Replacement

Liquidated Damages for Excess Annual Replacement ($) = Excess Annual Part Replacement Cost (Equation 11) Part x Present Worth Factor

3.06 UV DISINFECTION SYSTEM DATA SHEET

A. Following table summarizes data for the UV disinfection system:

Description	Data	Units
UV Lamp technology	Medium pressure	
Total number of UV reactors	3	each
Minimum no. of duty reactors	1	each
Maximum no. of duty rectors	2	each
Number of standby reactors	1	each
Water temperature range	36 to 88	degrees F
Turbidity	0.03 to 0.21	NTU
Hardness	75 to 183	mg/l as $CaCO_3$
pH	6 to 9	std units
Alkalinity	29 to 101	mg/l as $CaCO_3$
Iron (90th percentile value)	.032	mg/l
Manganese (90th percentile value)	0.014	mg/l
Peak flow rate	44	MGD
Peak flow rate per reactor	22	MGD
Average flow rate	23.5	MGD
Minimum flow rate	10.0	MGD
Minimum validated UV dose	8.5	mj/cm^2
Design UV transmittance (95th percentile)	95	%

Minimum validated UV transmittance	80	%
Lamp percent output defining end of lamp life (EOLL)	70	%
System operating pressure range	2 to 20	feet of water
System design pressure	50	psig
Maximum head loss through reactor	15	inches

END OF SECTION