CITY OF EVANSTON

SPECIFICATIONS AND BID DOCUMENTS
Construction Bid with Subcontractors

Volume 2 of 2

BID NUMBER: 22-35
For
1909 Raw Water Intake Replacement
Dated: April 14, 2022

BID DUE DATE:	**2:00 P.M., Tuesday, May 31st, 2022**
VIRTUAL BID OPENING	**2:15 P.M., Tuesday, May 31st, 2022** **Google Meet ID:** meet.google.com/erk-vjyw-pza **Phone Numbers:** (US)+1 617-675-4444 PIN: 491 020 418 0044#
MANDATORY PRE-BID MEETING:	**11:00 A.M., Thursday, April 28th, 2022** **Evanston Water Utility** **555 Lincoln Street, Evanston, Illinois 60201** **For security reasons, all parties interested in attending the mandatory pre-bid meeting must submit the Non-Disclosure Agreement (see Section 00-52-10) and a list of employee names that will be attending the meeting to Paul Moyano at pmoyano@cityofevanston.org by close of business April 25, 2022 in order to attend.**
BID BOND:	**5% of Contract Amount**
PERFORMANCE/MATERIAL & LABOR PAYMENT BOND:	**100% of Contract Amount**
CONTRACT PERIOD:	**686 days following Notice to Proceed**

ELECTRONIC BID SUBMITTAL:
Bid responses will only be accepted electronically
via E-bidding through DemandStar (WWW.DEMANDSTAR.COM)
It is highly recommended that new DemandStar users complete the account setup process prior to project due date/time.

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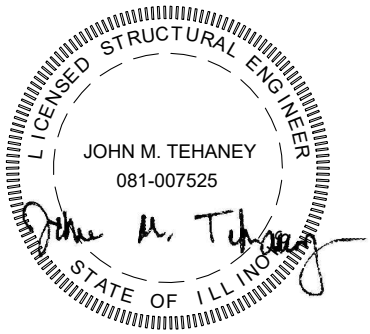
SEALS PAGE: EVANSTON 1909 RAW WATER INTAKE REPLACEMENT



License #: 062-059802____

Current Date: 04/04/2022_

EXP. Date: 11-30-2023____

License #: 081-007525____

Current Date: 04/04/2022_

EXP. Date: 11-30-2022____

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CITY OF EVANSTON
1909 Raw Water Intake Replacement
PROJECT MANUAL

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SECTION 03 01 30 - CONCRETE REPAIR AND REHABILITATION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Remove, repair, or rehabilitate new and existing concrete members and surfaces as indicated.

B. Provide all materials and equipment necessary to accomplish the WORK.

C. Repair damage to concrete and concrete surfaces which results from the removal of embedded items, from construction activities, or which existed previously in structures indicated to be repaired.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ACI 201.1R-08	Guide for Making a Condition Survey of Concrete in Service
ACI 546R-14	Concrete Repair Guide

1.3 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Submit Shop Drawings for strengthening required around new openings.

2. Submit detailed drawings showing proposed methods for supporting existing structures, equipment, and piping during demolition and repair activities.

C. Concrete Repair Products and Procedures

1. Submit a comprehensive plan for each repair method indicated within this Section, the plan shall including the following:

a. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, curing, and appropriate uses for each product.

b. Curing products and procedures for each repair method for which curing is recommended by the manufacturer.

1.4 QUALITY ASSURANCE

A. Field Tests of Cement Based Mortars and Grouts

1. The ENGINEER may take compression test specimens during construction from the first placement of each type of mortar or grout, and at intervals thereafter as selected by the ENGINEER in order to ensure continued compliance with the indicated requirements.

2. The CONTRACTOR shall assist the ENGINEER in obtaining specimens for testing.

3. The compression tests and fabrication of specimens for repair mortar and non-shrink grout will be performed as specified in ASTM C 109.

4. A set of 5 specimens will be made for testing at 7 days, 28 days, and additional time periods as appropriate.

5. Any material, already placed, which fails to meet the indicated performance requirements is subject to removal and replacement as part of the WORK.

6. The cost of laboratory tests on mortar and grout will be paid by the OWNER, but the CONTRACTOR shall be responsible for the cost of any additional tests and investigation on the WORK that does not meet the indicated requirements.

7. The CONTRACTOR shall supply all necessary materials for fabricating the test specimens.

B. Repair Concrete: Repair concrete shall be tested as required in Section 03 31 00 – Cast-in-Place Concrete.

C. Epoxy Grout: Epoxy grout shall be tested as required in Section 03 60 00 – Grouting.

D. Construction Tolerances: Construction tolerances shall comply with the requirements of Section 03 31 00 – Cast-in-Place Concrete, except as otherwise indicated.

PART 2 -- PRODUCTS

2.1 GENERAL

A. All products and materials in contact with potable water shall be certified as being in conformance with ANSI/NSF Standard 61 – Drinking Water System Components – Health Effects.

2.2 REPAIR MORTAR

A. Provide repair mortar as a pre-packaged, 2-component, polymer-modified, cementious, non-sag mortar, specifically formulated for the repair of surface defects.

B. Provide the mortar with a penetrating corrosion inhibitor.

C. Repair mortar shall have the following properties:

Physical Property	Value	ASTM Standard
Compressive Strength (min.)		C-109
at 7 days	6000 psig	
at 28 days	7000 psig	
Bond Strength (min.)		C-882 (modified)
at 28 days	2200 psig	
Freeze/Thaw resistance (min.)		C-666
300 cycles	98 percent	

D. Provide a minimum repair thickness of 1/4 inch, unless otherwise indicated.

E. Repair Mortar shall be **SikaTop 123 Plus**, by **Sika Corporation**, or equal.

2.3 NON-SHRINK GROUT

A. Provide non-shrink grout conforming to the requirements of Section 03 60 00 – Grouting.

2.4 CONCRETE MATERIALS

A. Cement

1. Use Type II Portland cement unless otherwise indicated.

2. Where repairs are to be made on wall surfaces open to view and above normal water surface elevations, blend white Portland cement with the Type II cement as needed in order to match the color of the adjacent existing concrete surface.

B. Structural Repair Grout

1. Where required, provide structural repair grout meeting the requirements of Section 03 60 00 – Grouting.

2. Provide a minimum repair thickness of 3 inches.

C. Cement Grout

1. Provide cement grout that meets the requirements of Section 03 60 00 – Grouting.

2. Provide a minimum repair thickness of one inch.

D. Miscellaneous Materials**:** For concrete construction materials not covered specifically in this Section, conform to the requirements of Section 03 31 00 – Cast-in-Place Concrete.

2.5 AGGREGATE

A. Obtain the written permission of the manufacturer and ENGINEER before using aggregate to extend repair mortar and grout products.

B. If allowed and unless otherwise indicated, provide aggregate consisting of 3/8-inch clean, washed gravel or crushed stone as required in Section 03 31 00 – Cast-in-Place Concrete.

2.6 BONDING AGENT AND ANTI-CORROSION COATING

A. Provide a bonding agent that is a solvent-free, moisture-tolerant, epoxy-modified, cementitious product, specifically formulated as a bonding agent and anti-corrosion coating.

B. Bonding Agent shall be **Armatec 110 EpoCem**, by **Sika Corporation**, or equal.

2.7 EPOXY GROUT

A. Provide an epoxy grout conforming to the requirements of Section 03 60 00 – Grouting.

2.8 EPOXY RESIN

A. Use epoxy resin for structural crack repair.

B. For crack injection, provide a 2-component, moisture-tolerant, low-viscosity, high-strength epoxy resin adhesive that is specially formulated for that usage.

C. Provide a minimum bond strength of 2900 psi when tested per ASTM C 882 at 14 days, moist cured.

D. Epoxy Resin shall be **Sikadur 35, Hi-Mod LV**, by **Sika Corporation**, **KEMKO 068 LoVis IR**, by **ChemCo Systems, Inc.**, or equal.

2.9 FORMWORK

A. Where needed, provide formwork that meets the requirements of Section 03 11 00 – Concrete Formwork.

2.10 REINFORCEMENT STEEL

A. Where required, provide reinforcing steel that meets the requirements of Section 03 21 00 – Reinforcement Steel.

2.11 POLYURETHANE SEALANT

A. Provide a 2-part polyurethane, gun-grade sealant.

B. Polyurethane Sealant shall be **Sikaflex – 2C**, by **Sika Corporation**, or equal.

2.12 POLYURETHANE CHEMICAL GROUT

A. Use polyurethane chemical grout for non-structural crack repair.

B. Polyurethane Chemical Grout shall be **SikaFix HH**, by **Sika Corporation**, **Flex LV PURe**, by **WR Grace/De Neef**, **Flex SLV PURe**, by **WR Grace/De Neef**, or equal.

2.13 HYDROPHILIC WATERSTOP

A. Provide hydrophilic waterstop of the type which expands in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.

B. Provide hydrophilic waterstop that is bentonite-free, and manufactured from chloroprene rubber and modified chloroprene rubber with hydrophilic properties.

C. Hydrophilic Waterstop shall be **Hydrotite RSS-040 P**, by **Greenstreak Group, Inc.**, KM **4mm String**, by **Adeka Ultra Seal**, or equal.

2.14 HIGH STRENGTH EPOXY GEL

A. High-Strength Epoxy Gel for crack surface sealing shall be **Denepox Rapidgel**, by **WR Grace/De Neef**, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Repairs

1. Repair techniques will be reviewed during the pre-construction meeting between the CONTRACTOR, ENGINEER, and OWNER.

2. The CONTRACTOR shall be familiar with the cause of deteriorated concrete and shall choose the right equipment, repair materials and techniques to be used for each particular repair.

3. Choose repair materials to match the adjacent concrete surface in color and texture.

4. Apply repair materials in strict accordance with the manufacturer's printed instructions, including temperature and moisture requirements throughout application and curing.

5. Protect adjacent portions of the structure, including all valves, pipes and mechanical equipment from debris generated by repair activities.

6. For portions of the structure that are not identified to be repaired, maintain in their original condition.

B. Structural Stability

1. Use caution not to weaken the structural capacity of a beam, column, wall, slab, walkway, or other concrete member during concrete removal.

2. For severely deteriorated concrete members, consult with the ENGINEER before removing a major portion of any structural member.

3. Shoring may be required in order to support the structure and to protect workers.

C. Shoring

1. Provide shoring below Shorewell No. 3 suspended slab at EL -10.75 prior to the start of repairs, including surface preparation and concrete removal.

2. Design the shoring to adequately distribute the load to the bottom slab of the Shorewell No. 3 structure in such a manner as to avoid damage to the interior suspended slabs.

3. Maintain the shoring in place until all repairs are completed and structurally repaired areas have achieved their full 28-day design strengths.

D. Provide off-site disposal of debris generated as a result of repair procedures.

E. Provide concrete construction procedures not specifically addressed in this Section in accordance with the requirements of Section 03 31 00 – Cast-in-Place Concrete.

3.2 REPAIR SEQUENCING

A. Unless otherwise indicated, perform concrete repairs in the following sequence, with no activity in an area being started until previous activities in that area have been completed, including curing, cleanup, and the like:

1. removal of equipment, miscellaneous metals, and other surface features that would interfere with the repair;

2. removal of concrete sections which require complete replacement;

3. surface preparation hydroblasting over the entire area to be repaired;

4. embedded metal repair;

5. crack repair;

6. spalled and delaminated concrete repair;

7. scaled concrete;

8. pop-out repair, and repair of other surface damage, deterioration, or defects;

9. patching of holes in concrete;

10. replacement of concrete sections which require complete replacement;

11. new construction; and,

12. application of protective coatings.

B. For areas which require combinations of spalled and delaminated concrete repair, scaled concrete, and pop-out repair, perform these repairs at the same time.

C. Limit the size of the repair area in order to permit the repairs to be performed together, without sacrificing the quality of the individual repairs.

3.3 EMBEDDED METAL REPAIR

A. Unless otherwise indicated, repair anchor bolts and other embedded metal, except rebar, that are exposed at the concrete surface and are showing signs of corrosion, as follows:

1. Cut off or otherwise remove corroded metal fastened at the surface;

2. Burn back embedded metals to a depth of at least 1.5 inches beyond the surface of sound concrete;

3. Chip away unsound concrete around the embedded metal.

4. Apply epoxy grout to the repair area until level with the surface of the surrounding sound concrete.

B. Unless otherwise indicated, repair embedded rebar that is exposed at the concrete surface following the procedures outlined in the appropriate concrete repair subsection, below.

3.4 CRACK REPAIR

A. Structural Cracks - Structural Cracks are defined as follows:

1. All cracks where reinforcing steel is passing across the crack, including erratic cracks, and cracks at construction joints.

2. Repair structural cracks with epoxy resin.

B. Non Structural Cracks - Non Structural Cracks are defined as follows:

1. Cracks occurring at flexible joints, contraction joints or expansion joints.

2. Repair non-structural cracks with polyurethane chemical grout.

C. Efflorescence

1. Prior to the crack repair, clean efflorescence from the cracks and the surrounding area.

2. Clean the efflorescence by light hydro-blasting or scrubbing.

D. Pressure Injection: Pressure Injection to be performed prior to leak testing and roof membrane installation.

1. General

a. The indicated repair materials have been selected to minimize the loss of material during the injection process. The areas selected for crack repair are to be identified by the Contractor, Engineer or Construction Manager and be determined prior to leak tests and roof membrane installation. The injection of cracks may also be required as a result of the leak test.

b. In order to avoid excessive loss of injected material at the lower exposed portions of the cracks, space the injection ports a distance no greater than the thickness of the wall being repaired.

2. Open through thickness structural cracks are to be repaired to deliver a water tight hydraulic structure passing the specified leakage test. All 3 foot long minimum or greater through thickness cracks greater than a minimum 15 mil thickness in the walls are to be injected unless they do not accept grout. All 2 foot long minimum through thickness cracks greater than 10 mil thickness in the foundation, water conduits, floor slabs and roof are to be injected unless they do not accept grout. Perform structural crack repairs by pressure injection in accordance with the manufacturer’s directions, and in accordance with the following basic procedure:

a. Remove unsound and foreign materials from the crack in a manner that does not trap debris in the crack and prevent the flow of repair materials.

b. Remove any contamination by flushing with water or solvent, allowing adequate time for air-drying or blow out the solvent with compressed air. For potable water applications, any solvents must be fully flushed from the joint unless NSF/ANSI Standard 61 approved.

c. Install the injection ports in accordance with the manufacturer's directions.

d. Sealing

1) Seal the surface in order to keep the pressure injecting materials from leaking out before it has set or gelled.

2) Seal a surface by brushing an epoxy over the surface of the crack and allowing it to harden, or use high injection pressures to cut-out the cracks in a 'V' shape, fill with an epoxy, and strike off flush with the surface.

3) Surface patching or sealant shall be performed where needed to provide for complete penetration of the injected polyurethane grout and to prevent wastage. Seal surface of crack with fast setting hydraulic cement or high strength epoxy gel. The floor surface along the cracks shall be cleaned and all wasted grout and surface seal material shall be completely removed from the concrete surface following completion of the repair work

e. Inject the repair materials, with consideration of the following items:

1) Carefully select the pressure of the hydraulic pump or other device, because too much pressure can extend the existing cracks and cause more damage.

2) For vertical cracks, start by pumping material into the entry port at the lowest elevation until the material level reaches the entry port above, then cap the lower injection port and repeat the process at successively higher ports until the crack has been completely filled.

3) For horizontal cracks, start at one end of the crack and work to the other end, filling the crack until the pressure can be maintained.

4) For very fine cracks, start the injection of repair material at the widest end and proceed toward the thinner end, using low-viscosity repair material.

f. Cleanup

1) Remove the surface seal by grinding or other appropriate means.

2) Coat fittings and holes at injection ports with an epoxy patching compound.

3) If crack repairs are part of repair for surface defects, painting with epoxy is not necessary and surface preparation may be started after crack repairs have been completed.

3. Open through thickness non-structural cracks are to be repaired to deliver a water tight hydraulic structure passing the specified leakage test. Open through thickness

cracks with lengths of at least 3 feet on each side of the wall and roof, at least 2 feet of length on the foundation or floor slab are to be injected unless they do not accept grout. All 3 foot long minimum or greater through thickness cracks greater than a minimum 15 mil thickness in the walls are to be injected unless they do not accept grout. All 2 foot long through thickness cracks greater than 10 mil thickness in the floors and roof are to be injected unless they do not accept grout. Perform non-structural crack repairs in accordance with the manufacturer's directions, and in accordance with the following basic procedure:

a. Remove unsound and foreign materials from the crack in a manner that does not trap debris in the crack and prevent the flow of repair materials.

b. Remove contamination by flushing with water or solvent, allowing adequate time for air-drying or blow out the solvent with compressed air. Any solvents must be fully flushed from the joint unless NSF/ANSI Standard 61 approved.

c. Install the injection ports in accordance with the manufacturer's directions.

d. Moisture

    1) For non-structural cracks, moisture must be present for the chemical grout to react.

    2) Prior to injecting the repair materials, inject the crack with a small amount of water in order to completely moisten the crack.

e. Inject the repair materials, with consideration of the following items:

    1) Carefully select the pressure of the hydraulic pump or other device, because too much pressure can extend the existing cracks and cause more damage.

    2) For vertical cracks, start by pumping material into the entry port at the lowest elevation until the material level reaches the entry port above, cap the lower injection port and repeat the process at successively higher ports until the crack has been completely filled, and then, starting again at the lowest port, re-inject into all ports in order to ensure that all voids are properly sealed off.

    3) For horizontal cracks, start at one end of the crack and work to the other end, filling the crack until the pressure can be maintained.

    4) For very fine cracks, start the injection of repair material at the widest end and proceed toward the thinner end.

f. Cleanup

    1) Remove excess surface material by grinding or other appropriate means.

    2) Coat fittings and holes at injection ports with an epoxy patching compound.

    3) If crack repairs are part of repair for surface defects, painting with epoxy is not necessary and surface preparation may be started after crack repairs have been completed.

3.5 SPALLED AND DELAMINATED CONCRETE REPAIR

A. Repair spalls and delaminated concrete using repair mortar.

B. Surface Preparation

1. Remove all delaminated concrete and all unsound concrete beyond the spalled or delaminated area.

2. Boundaries

a. Determine the boundaries of the patch by sawcuts to a depth of at least 1/4 inch up to one inch deep.

b. Refer to the Structural Drawings for sawcut locations.

c. Where the sawcut locations are not shown on the Drawings, the boundaries shall be layouts designed to reduce boundary edge length.

d. Avoid excessive or complex edge conditions.

3. Sawcuts

a. Perform sawcuts perpendicular to the surface or slightly undercut.

b. Construct sawcuts in maximum 1/4-inch increments.

c. After each incremental cut, inspect the cut surface in order to ensure that the existing reinforcement has not been cut.

d. If at any depth the reinforcement becomes exposed, terminate the sawcut and notify the ENGINEER.

4. Chip away concrete within the repair area to a depth sufficient to expose sound concrete over the entire repair area, or to a minimum depth required by repair mortar, whichever is greater.

5. Base the selection of partial depth concrete removal equipment on the size of repair area, depth of concrete to be removed, and the location of the deteriorated concrete such as wall, slab-on-grade, underside or top of elevated slab.

6. Removal

a. The maximum allowable pneumatic chipping hammer shall be a 30-lb class hammer.

b. Hydroblast removal shall use a maximum pressure of 40,000 psig.

c. Sand blasting is not permitted.

d. Hydroblast concrete removal is recommended for large area of surface defects.

e. Remove water blasting debris daily in order to prevent it from setting up.

f. If a chipping hammer is used, ensure that the existing reinforcement is not damaged during the concrete removal operations.

g. Remove protrusions, such as mortar spatter or fins, by grinding or by striking with a hammer or other tool.

7. Reinforcement

a. Remove concrete from around reinforcement when the rebar is rusted, more than half the rebar perimeter is already exposed, the concrete bond around the rebar is broken, or if the concrete is unsound or honey-combed.

b. Remove concrete in order to provide a clear space of minimum one inch on all sides of the reinforcement, such that the rebar can be cleaned and the repair material will completely surround the rebar.

c. Clean exposed reinforcement by water blasting or wire brushing.

d. After fully exposing and cleaning the reinforcement, check for steel deterioration, and if the cross-sectional area of the steel has been reduced by more than 10 percent, whether by deterioration, surface preparation, or a combination of both, provide additional reinforcement.

e. Consult with the ENGINEER before adding or replacing rebar.

C. Repairing Surface Defects

1. Clean the concrete surface after removing unsound concrete, repairing cracks, and cleaning the reinforcement.

2. Ensure that the concrete surface and reinforcement are free of form-release agents, curing compounds, surface hardeners, oils, grease, food, chemicals, and other contaminants.

3. Remove dust, including new dust generated by surface preparation or scarifying.

4. Prior to application of the bonding agent, apply anti-corrosion coating to exposed rebar in accordance with the manufacturer’s recommendations, allow the coating to dry, reapply the coating, and allow to dry again.

5. Prior to applying the repair mortar, apply bonding agent in accordance with the manufacturer’s recommendations.

6. Repair Mortar

a. Apply repair mortar in accordance with the manufacturer’s recommendations.

b. The thickness of each lift of repair mortar shall be in accordance with the manufacturer’s recommendations, with the minimum thickness being not less than 1/4 inch.

7. Fully consolidate the repair mortar, working the material into the substrate to completely fill all pores and voids in the area to be filled.

8. Bring the repair surface into alignment with the adjacent existing surfaces in order to provide a uniform, even surface.

9. Match the repair surface to adjacent existing surfaces in texture by applying necessary coatings and surface treatments.

10. Float-finish the repaired surface using wood or sponge floats.

11. For repaired surfaces to receive a protective coating, brush-finish the surface in order to produce a roughened substrate for the coating.

12. Minimum and maximum ambient and surface temperatures shall be as recommended by repair material manufacturer.

D. Curing

1. Where repair mortar is not to receive waterproofing, provide curing in accordance with the manufacturer's recommendations except that the minimum cure period shall be 7 days.

2. During cold weather, maintain the repair material temperature above 50 degrees F for at least 3 days after placement.

3.6 SCALED CONCRETE REPAIR

A. Repair scaling and pop-outs using repair mortar.

B. Surface Preparation

1. Prior to repair, prepare the surface in accordance with the repair mortar manufacturer's recommendations with the following minimum requirement.

2. Remove unsound concrete from surfaces by high-pressure water blasting, using a minimum pressure of 10,000 psigg and maximum pressure of 40,000 psigg.

3. Clean exposed reinforcement by water blasting or wire brushing.

C. Repairing Surface Defects

1. Clean the concrete surface after removing unsound concrete, repairing cracks, and cleaning reinforcement.

2. Ensure that the concrete surface and reinforcement are free of form-release agents, curing compounds, surface hardeners, oils, grease, food, chemicals, and other contaminants.

3. Remove dust, including new dust generated by surface preparation or scarifying.

4. Prior to application of the bonding agent, apply anti-corrosion coating to exposed rebar in accordance with the manufacturer's recommendations, allow the coating to dry, reapply the coating, and allow to dry again.

5. Prior to applying the repair mortar, apply bonding agent in accordance with the manufacturer's recommendations.

6. Apply repair mortar in accordance with the manufacturer's recommendations, using a minimum repair material thickness of 1/4 inch.

7. Fully consolidate the repair material, working the material into the substrate to completely fill all pores and voids in the area to be filled.

8. Bring the repair surface into alignment with the adjacent existing surfaces in order to provide a uniform, even surface.

9. Match the repair surface to adjacent existing surfaces in texture by applying necessary coatings and surface treatments.

10. Float-finish the repaired surface using wood or sponge floats.

D. Provide strip joint in newly placed mortar at the location of repaired cracks.

E. Curing

1. Where the repair mortar is not to receive waterproofing, provide curing in accordance with the manufacturer's recommendations except that the minimum cure period shall be 7 days.

2. During cold weather, maintain the repair material temperature above 50 degrees F for at least 3 days after placement.

3.7 POP-OUT REPAIR, AND REPAIR OF OTHER SURFACE DAMAGE, DETERIORATION, OR DEFECTS

A. Repair pop-outs and other surface damage, deterioration, and defects which are 1/4 inch deep or shallower, using the procedures described under "SCALED CONCRETE REPAIR," above.

B. Repair other pop-outs and surface damage, deterioration, and defects using the procedures described under "SPALLED AND DELAMINATED CONCRETE REPAIR," above.

3.8 REPLACEMENT OF CONCRETE SECTIONS WHICH REQUIRE COMPLETE REPLACEMENT

A. Refer to the Structural Drawings for locations where the level of concrete deterioration is such that complete removal and replacement of the deteriorated section is required.

B. At these locations, remove the deteriorated concrete in accordance with the details on the Structural Drawings and the requirements of this Section.

C. Limits

1. The limits of concrete removal shall be as indicated on the Structural Drawings.

2. If no limits of removal are indicated, determine the limits in accordance with the procedures described under "Boundaries – Spalled and Delaminated Concrete Repair."

D. Provide sawcuts in accordance with the procedures described under "Sawcuts – Spalled and Deliminated Concrete Repair."

E. After removal of the concrete, prepare the area and provide repair concrete in accordance with the details on the Structural Drawings and the requirements of this Section.

F. Unless otherwise indicated, match the finished cross-section of the repaired concrete to the cross-section of the adjacent undamaged concrete.

3.9 PATCHING OF HOLES IN CONCRETE

A. General

1. For the purposes of this Section, holes are defined as penetrations completely through the concrete member and with interior surfaces approximately perpendicular to the surface of the existing member.

2. Interior surface areas which are inclined and do not meet this criteria shall be chipped as needed to meet this requirement.

3. The perimeter of holes at the surface shall form a regular shape composed of curved or straight line segments.

4. Provide the minimum depth of placement for the material used; score the existing concrete by sawcutting, and chip as needed to meet this requirement.

5. Roughen the interior surface of holes less than 12 inches in diameter to a minimum of 0.125-inch amplitude, and roughen larger holes to a minimum of 0.25-inch amplitude.

6. At holes, coat the existing surface to be repaired with a bonding agent.

B. Patching Small Holes: For holes which are less than 12 inches in their least dimension and extend completely through concrete members, fill with non-shrink grout.

C. Patching Large Holes

1. Fill holes which are larger than 12 inches in their least dimension with structural repair grout.

2. Provide large holes which are normally in contact with water or soil with hydrophilic waterstop placed in a groove.

3. Alternatively, bond the hydrophilic waterstop to the surface using an epoxy grout which completely fills all voids and irregularities beneath the waterstop material.

4. Install the waterstop in accordance with the requirements of Section 03 32 00 – Joints in Concrete.

5. Provide reinforcing steel in layers matching existing reinforcement location, size, spacing and cover requirements unless directed otherwise by the ENGINEER.

6. In locations where NSF/ANSI Standard 61 approval is required by the authority having jurisdiction, use one of the following procedures:

a. Provide Product Data showing the proposed structural repair grout is NSF/ANSI Standard 61 approved.

b. Complete the repair with structural repair grout. Coat all surfaces required to have NSF/ANSI Standard 61 approval completely with Sikadur 31, Tyfo S, or equal.

c. Place the structural repair grout to within 1 ½" of the finished surface of the repair. Complete the remainder of the repair with SikaTop123 Plus, or equal.

3.10 PATCHING OF LINED HOLES

A. General

1. This WORK applies to those openings which have embedded material over all or a portion of their inside edge.

2. The requirements for repairing holes in concrete, as indicated above, apply as modified herein.

3. The ENGINEER will determine whether the embedded material is allowed to remain.

B. Where embedded material is allowed to remain, trim it back a minimum of 2 inches from the concrete surface.

C. Roughen or abrade the embedded material in order to promote good bonding to the repair material.

D. Remove substances that interfere with good bonding.

E. Completely remove embedded items that are not securely and permanently anchored into the concrete.

F. Completely remove embedded items which are larger than 12 inches in their least dimension, unless they are composed of a metal to which reinforcing steel can be welded; where reinforcement is required, weld it to the embedded metal.

G. The following requirements shall apply to concrete members which are in contact with water or soil:

1. Using epoxy grout, fill lined openings which are less than 4 inches in their least dimension;

2. Using an epoxy bonding agent, coat lined openings which are greater than 4 inches but less than 12 inches in their least dimension, prior to being filled with non-shrink grout.

3. Using an epoxy bonding agent, coat lined openings which are greater than 12 inches in their least dimension, and provide a hydrophilic waterstop bonded to the interior of the opening with epoxy adhesive, prior to being filled with approved repair material.

END OF SECTION

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SECTION 03 11 00 - CONCRETE FORMING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall furnish concrete formwork, bracing, shoring, and supports for cast-in-place concrete and shall design and construct falsework, all in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Manufacturer’s information demonstrating compliance with requirements for the following:

1. Form ties and related accessories, including taper tie plugs, if taper ties are used.

2. Form gaskets.

3. Form release agent, including NSF certification if not using mineral oil.

4. Manufacturer's design information on formwork, form materials, and locations for use.

1.3 QUALITY ASSURANCE

A. Tolerances: The variation from required lines or grade shall not exceed 1/4-inch in 10-feet, non-cumulative, and there shall be no offsets or visible waviness in the finished surface. Other tolerances shall be within the tolerances of ACI 117 - Standard Tolerances for Concrete Construction and Materials

PART 2 -- PRODUCTS

2.1 GENERAL

A. Except as otherwise expressly accepted by the ENGINEER, lumber brought on the Site for use as forms, shoring, or bracing shall be new material. Forms shall be smooth surface forms and shall be of the following materials:

Walls	Steel, fiberglass, or plywood panel
Columns	Steel, plywood or fiberglass
Roof and floor	Plywood
All other WORK	Steel panels, fiberglass, plywood or tongue and groove lumber

B. Form materials that may remain or leave residues on or in the concrete shall be certified as compliant with NSF Standard 61 – Drinking Water System Components.

C. Water-based form release agent shall be **Clean Strip J1EF** by **Dayton Superior**, or equal.

2.2 FORM AND FALSEWORK MATERIALS

A. Materials for concrete forms, formwork, and falsework shall conform to the following requirements:

1. Lumber shall be Douglas Fir or Southern Yellow Pine, construction grade or better, in conformance with U.S. Product Standard PS 20 - American Softwood Lumber Standard

2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Yellow Pine plywood manufactured especially for concrete formwork, shall conform to the requirements of PS 1 – Construction and Industrial Plywood, for Concrete Forms, Class I, and shall be edge sealed.

3. Form materials shall be metal, wood, plywood, or other material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line, and grade indicated. Metal forms shall accomplish such results. Wood forms for surfaces to be painted shall be Medium Density Overlaid plywood, MDO Ext. Grade.

4. Steel leave in place forms shall not be used.

B. Unless otherwise indicated, exterior corners in concrete members shall be provided with 3/4-inch chamfers or be tooled to 1/2-inch radius. Re-entrant corners in concrete members shall not have fillets unless otherwise indicated.

C. Forms and falsework to support the roof and floor slabs shall be designed for the total dead load, plus a live load of 50 psf minimum. The minimum design load for combined dead and live loads shall be 100 psf.

2.3 FORM TIES

A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to insure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties or other removable form tie fasteners having a circular cross-section shall not exceed 1-1/2 inches; and all such fasteners shall be such as to leave holes of regular shape for reaming. Form ties for water-retaining structures shall have integral waterstops that tightly fit the form tie so that they cannot be moved from mid-point of the tie. Form ties shall be **ST-4 Hex Head Snaptie** by **MeadowBurke, Snap-Ties** by **Dayton/Richmond,** or equal.

B. Removable taper ties may be used when approved by the ENGINEER. A preformed neoprene or polyurethane tapered plug sized to seat at the center of the wall shall be inserted in the hole left by the removal of the taper tie**.** Use **HD-9 Taper-Tie** by **MeadowBurke, Taper-Tie** by **Dayton/Richmond,** or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Forms to confine the concrete and shape it to the required lines shall be used wherever necessary. The CONTRACTOR shall assume full responsibility for the adequate design of forms, and any forms that are unsafe or inadequate in any respect shall promptly be removed from the WORK and replaced. Provide worker protection from protruding reinforcement bars in accordance with applicable safety codes. A sufficient number of forms of each kind shall be available to permit the required rate of progress to be

maintained. The design and inspection of concrete forms, falsework, and shoring shall comply with applicable local, state, and Federal regulations. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by CONTRACTOR's personnel and by the ENGINEER and shall be in sufficient number and properly installed. During concrete placement, the CONTRACTOR shall continually monitor plumb and string line form positions and immediately correct deficiencies.

B. Concrete forms shall conform to the shape, lines, and dimensions of members required, and shall be substantial, free from surface defects, and sufficiently tight to prevent leakage. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly-placed concrete. If adequate foundation for shores cannot be secured, trussed supports shall be provided.

C. Forms shall be removed unless approved otherwise by the ENGINEER.

3.2 FORM DESIGN

A. Forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade, and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. Suitable and effective means shall be provided on forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Plywood, 5/8-inch and greater in thickness, may be fastened directly to studding if the studs are spaced close enough to prevent visible deflection marks in the concrete. The forms shall be tight so as to prevent the loss of water, cement, and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1- to 1-1/2-inch diameter polyethylene rod held in position to the underside of the wall form. Adequate clean-out holes shall be provided at the bottom of each lift of forms. The size, number, and location of such clean-outs shall be as acceptable to the ENGINEER. Whenever concrete cannot be placed from the top of a wall form in a manner that meets the requirements of the Contract Documents, form windows shall be provided in the size and spacing needed to allow placement of concrete to the requirements of Section 03 31 00 - Cast-in-Place Concrete. The size, number, and location of such form windows shall be as acceptable to the ENGINEER.

3.3 CONSTRUCTION

A. Vertical Surfaces: Vertical surfaces of concrete members shall be formed, except where placement of the concrete against the ground is indicated. Not less than 1-inch of concrete shall be added to the indicated thickness of a concrete member where concrete is permitted to be placed against trimmed ground in lieu of forms. Permission to do this on other concrete members will be granted only for members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.

B. Construction Joints: Concrete construction joints will not be permitted at locations other than those indicated, except as may be acceptable to the ENGINEER. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location, and tightening of ties at the top of the old lift and bottom of the new to

prevent any unsatisfactory effect whatsoever on the concrete. Pipe stubs and anchor bolts shall be set in the forms where required.

C. Form Ties

1. Embedded Ties: Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar. Wire ties for holding forms will not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete members. The use of snap-ties that cause spalling of the concrete upon form stripping or tie removal will not be permitted. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 1-inch back from the formed face or faces of the concrete.

2. Removable Ties: Where taper ties are approved for use, the larger end of the taper tie shall be on the wet side of walls in water retaining structures. After the taper tie is removed, the hole shall be thoroughly cleaned and roughened for bond. A precast neoprene or polyurethane tapered plug shall be located at the wall centerline. The hole shall be completely filled with non-shrink grout for water bearing and below-grade walls. The hole shall be completely filled with non-shrink or regular cement grout for above-grade walls that are dry on both sides. Exposed faces of walls shall have the outer 2-inches of the exposed face filled with a cement grout that shall match the color and texture of the surrounding wall surface.

3.4 REUSE OF FORMS

A. Forms may be reused only if in good condition and only if acceptable to the ENGINEER. Light sanding between uses will be required wherever necessary to obtain uniform surface texture on exposed concrete surfaces. Exposed concrete surfaces are defined as surfaces which are permanently exposed to view. In the case of forms for the inside wall surfaces of hydraulic/water retaining structures, unused tie rod holes in forms shall be covered with metal caps or shall be filled by other methods acceptable to the ENGINEER.

3.5 REMOVAL OF FORMS

A. Careful procedures for the removal of forms shall be strictly followed, and this WORK shall be done with care so as to avoid injury to the concrete. No heavy loading on green concrete will be permitted. In the case of roof slabs and above-ground floor slabs, forms shall remain in place until test cylinders for the roof concrete attain a minimum compressive strength of 75 percent of the 28 Day strength in Section 03 31 00. No forms shall be disturbed or removed under an individual panel or unit before the concrete in the adjacent panel or unit has attained 75 percent of the 28 Day strength and has been in place for a minimum of 7 Days. The time required to establish said strength shall be as determined by the ENGINEER who will make several test cylinders for this purpose from concrete used in the first group of roof panels placed. If the time so determined is more than the 7 Day minimum, then that time shall be used as the minimum length of time. Forms for vertical walls of waterholding structures shall remain in place at least 36 hours after the concrete has been placed. Forms for parts of the WORK not specifically mentioned herein shall remain in place for periods of time as recommended in ACI 347 - Guide to Formwork for Concrete.

3.6 MAINTENANCE OF FORMS

A. Forms shall be maintained in good condition, particularly as to size, shape, strength, rigidity, tightness, and smoothness of surface. Before concrete is placed, the forms shall be thoroughly cleaned. The form surfaces shall be treated with a nonstaining mineral oil or other lubricant acceptable to the ENGINEER. Any excess lubricant shall be satisfactorily removed before placing the concrete. Where field oiling of forms is required, the CONTRACTOR shall perform the oiling at least 2 weeks in advance of their use. Care shall be exercised to keep oil off the surfaces of steel reinforcement and other metal items to be embedded in concrete.

3.7 FALSEWORK

A. The CONTRACTOR shall be responsible for the design, engineering, construction, maintenance, and safety of falsework, including staging, walkways, forms, ladders, and similar appurtenances, which shall equal or exceed the applicable requirements of the provisions of the OSHA Safety and Health Standards for Construction and the requirements herein.

B. Falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time.

C. Falsework shall be placed upon a solid footing, safe against undermining, and be protected from softening. When the falsework is supported on timber piles, the maximum calculated pile loading shall not exceed 20 tons. When falsework is supported on any portion of the structure which is already constructed, the load imposed by the falsework shall be spread, distributed, and braced in such a way as to avoid any possibility of damage to the structure.

END OF SECTION

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SECTION 03 21 00 - REINFORCEMENT STEEL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide reinforcement steel and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Furnish shop bending diagrams, placing lists, and drawings of reinforcement steel prior to fabrication.

2. Diagrams

a. The shop bending diagrams shall show the actual lengths of bars to the nearest inch, measured to the intersection of the extensions (tangents for bars of circular cross section) of the outside surface.

b. Include bar placement diagrams that clearly indicate the dimensions of each bar splice.

3. Reinforcement

a. Details of the concrete reinforcement steel and concrete inserts shall be submitted at the earliest possible date after receipt by the CONTRACTOR of the Notice to Proceed.

b. Said details of reinforcement steel for fabrication and erection shall conform to ACI 315 - Details and Detailing of Concrete Reinforcement, and the indicated requirements.

c. Mill certificates, including reinforcing steel yield and tensile strength test data.

4. Mechanical Couplers

a. Where mechanical couplers are required or permitted to be used to splice reinforcement steel, submit the following items:

1) manufacturer's literature containing instructions and recommendations for installation for each type of coupler used;

2) certified test reports that verify the load capacity of each type and size of coupler used; and

3) Shop Drawings that show the location of each coupler with details of how they are to be installed in the formwork.

5. Welding

   a. If reinforcement steel is to be spliced by welding at any location, submit mill test reports containing the information necessary for determination of the carbon equivalent per AWS D1.4 - Structural Steel Welding Code - Reinforcing Steel.

   b. Submit a written welding procedure for each type of weld for each size of bar which is to be spliced by welding; merely a statement that AWS procedures will be followed is not acceptable.

   c. If reinforcement steel is spliced by welding at any location, submit certifications of procedure qualifications for each welding procedure and certification of welder qualifications, for each welding procedure and for each welder performing on the WORK.

1.3 QUALITY ASSURANCE

A. Materials Testing

1. If requested by the ENGINEER, furnish samples from each heat of reinforcement steel in a quantity adequate for testing.

2. Costs of initial tests will be paid by the OWNER.

3. Costs of additional tests if material fails initial tests shall be the CONTRACTOR's responsibility.

B. Welding

1. Welder qualifications and procedure qualifications shall be as indicated in AWS D1.4.

2. If requested by the ENGINEER, furnish samples of each type of welded splice in a quantity and of dimensions adequate for testing.

3. At the discretion of the ENGINEER, radiographic testing of direct butt-welded splices will be performed.

4. Provide assistance necessary to facilitate testing.

5. Repair welds that fail to meet AWS D1.4.

6. The costs of testing will be paid by the OWNER, but the costs of tests that show failure to meet requirements shall be the CONTRACTOR's responsibility.

PART 2 -- PRODUCTS

2.1 MATERIAL REQUIREMENTS

A. Materials that may remain or leave residues on or within the concrete shall be certified as compliant with NSF Standard 61- Drinking Water System Components.

2.2 REINFORCEMENT STEEL

A. Reinforcement steel for cast-in-place reinforced concrete construction shall conform to the following requirements:

1. Bar and spiral reinforcement shall conform to ASTM A 615 - Deformed and Plain Billet - Steel Bars, for Grade 60 reinforcement, unless otherwise indicated.

2. Welded Reinforcement

    a. Bar and spiral reinforcement that is welded shall conform to ASTM A 706 - Low Alloy Steel Deformed and Plain Bars for Concrete Reinforcement, for Grade 60 reinforcement, unless otherwise indicated.

    b. The carbon equivalent in reinforcing that is welded shall not exceed 0.55 percent.

3. Welded Wire Reinforcement

    a. Welded wire reinforcement shall conform to ASTM A 1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete, and the indicated Details.

    b. Welded wire reinforcement with longitudinal wire of W4 size wire and smaller shall be in flat sheets or in rolls with a core diameter of not less than 10-inches.

    c. Welded wire reinforcement with longitudinal wires larger than W4 size shall be in flat sheets only.

B. Accessories

1. Accessories shall include necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers, and other devices to position reinforcement during concrete placement.

2. Bar Supports

    a. Bar supports shall meet the requirements of the CRSI Manual of Standard Practice, including special requirements for supporting epoxy-coated reinforcing bars.

    b. Wire bar supports shall be CRSI Class 1 for maximum protection with a 1/8-inch minimum thickness of plastic coating that extends at least 1/2 inch from the concrete surface.

    c. Plastic shall be gray in color.

3. Concrete Blocks

    a. Concrete blocks (dobies) used to support and position reinforcement steel shall have the same or higher compressive strength as required for the concrete in which they are located.

    b. Wire ties shall be embedded in concrete block bar supports.

C. Epoxy coating for reinforcing and accessories, where indicated, shall conform to ASTM A 775 - Epoxy - Coated Reinforcing Steel Bars.

2.3 MECHANICAL COUPLERS

A. Mechanical couplers shall be provided where indicated and where approved by the ENGINEER.

B. The couplers shall develop a tensile strength and compressive strength that exceeds 125 percent of the specified yield strength of the reinforcement bars being spliced at each splice, and shall develop the specified tensile strength of the reinforcement bars being spliced at each splice.

C. Multi-Component Couplers

1. Where the type of coupler used is composed of more than one component, components required for a complete splice shall be provided.

2. This shall apply to mechanical splices, including those splices intended for future connections.

D. Connection

1. The reinforcement steel and coupler used shall be compatible for obtaining the required strength of the connection.

2. Straight threaded type couplers shall require the use of the next larger size reinforcing bar or shall be used with reinforcing bars with specially forged ends which provide upset threads which do not decrease the basic cross section of the bar.

E. Couplers shall be **Lenton Form Saver** by **Erico Products, Dowel Bar Splicer System** by **Dayton/Richmond**, or equal.

2.4 WELDED SPLICES

A. Welded splices shall be provided where indicated and where approved by the ENGINEER.

B. Welded splices of reinforcement steel shall develop a tensile strength that exceeds 125 percent of the specified yield strength of the reinforcement bars that are connected.

C. Materials as required to conform the welded splices to AWS D1.4 shall be provided.

2.5 EPOXY GROUT

A. Epoxy for grouting reinforcing bars shall be specifically formulated for such application, for the moisture condition, application temperature, and orientation of the hole to be filled.

B. Epoxy grout shall be in conformance with the requirements of Section 03 60 00 – Grout.

PART 3 -- EXECUTION

3.1 GENERAL

A. Reinforcement steel, welded wire fabric, couplers, and other appurtenances shall be fabricated, and placed in accordance with the Building Code and the indicated supplementary requirements.

3.2 FABRICATION

A. General

1. Reinforcement steel shall be accurately formed to the dimensions and shapes indicated, and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318 - Building Code Requirements for Reinforced Concrete, except as modified by the Drawings.

2. Bars shall be bent cold.

3. Bars shall be bent in accordance with the requirements of ACI 318.

4. Fabricate reinforcement bars for structures in accordance with accepted bending diagrams, placing lists, and placing drawings.

B. Fabricating Tolerances

1. Bars used for concrete reinforcement shall conform to the following fabricating tolerances:

a. Sheared Length: plus and minus one inch

b. Depth of Truss Bars: plus zero, minus 1/2 inch

c. Stirrups, Ties and Spirals: plus and minus 1/2 inch

d. Other Bends: plus and minus one inch

3.3 PLACEMENT

A. Reinforcement steel shall be accurately positioned as indicated, and shall be supported and wired together to prevent displacement using annealed iron wire ties or suitable clips at intersections.

B. Reinforcement steel shall be supported by concrete, plastic or metal support spacers, or metal hangers that are sufficiently strong and rigid to prevent any displacement of the reinforcement steel.

C. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the bars without settlement, but in no case shall such support be continuous.

D. Concrete blocks used to support reinforcement steel shall be tied to the steel with wire ties that are embedded in the blocks.

E. For concrete over formwork, provide concrete, metal, plastic, or other acceptable bar chairs and spacers.

F. Limitations on the use of bar support materials shall be as follows.

1. Concrete Dobies

a. permitted at any location except where architectural finish is required

b. required for slabs on grade and surfaces in contact with or above ozonated process water

2. Wire bar supports will be permitted only at slabs over dry areas, interior dry wall surfaces, and exterior wall surfaces.

3. Plastic bar supports will be permitted at every location except on-grade.

G. Tie wires shall be bent away from the forms in order to provide the required concrete coverage.

H. Bars additional to those indicated that may be found necessary or desirable by the CONTRACTOR for the purpose of securing reinforcement in position shall be provided by the CONTRACTOR at no additional expense to the OWNER.

I. Except where in conflict with the Building Code, unless otherwise indicated reinforcement placing tolerances shall be within the limits in Section 7.5 of ACI 318.

J. Moving Bars

1. Bars may be moved as necessary to avoid interference with other reinforcement steel, conduits, or embedded items.

2. If bars are moved more than one bar diameter or enough to exceed the above tolerances, the resulting arrangement of bars shall be as reviewed and accepted by the ENGINEER.

K. Welded Wire Reinforcement

1. Welded wire reinforcement placed over horizontal forms shall be supported on slab bolsters.

2. Slab bolsters shall be spaced not more than 30-inch on centers, shall extend continuously across the entire width of the reinforcement mat, and shall support the reinforcement mat in the plane indicated.

3. Welded wire reinforcement placed over the ground shall be supported on wired concrete blocks (dobies) spaced not more than 3 feet on centers in any direction.

4. The construction practice of placing welded wire fabric on the ground and hooking into place in the freshly placed concrete shall not be used.

L. Storage and Handling

1. Epoxy-coated reinforcing bars shall be stored, transported, and placed in such a manner as to avoid chipping of the epoxy coating.

2. Non-abrasive slings made of nylon and similar materials shall be used.

3. Specially coated bar supports shall be used.

4. Chips or cracks in the epoxy coating shall be repaired with a compatible epoxy repair material prior to placing concrete.

M. Accessory Spacing

1. Accessories supporting reinforcing bars shall be spaced such that there is no deflection of the accessory from the weight of the supported bars.

2. When used to space the reinforcing bars from wall forms, the forms and bars shall be located such that there is no deflection of the accessory when the forms are tightened into position.

3.4 SPACING OF BARS

A. The clear distance between parallel bars (except in columns and between multiple layers of bars in beams) shall be not less than the nominal diameter of the bars, nor less than 1-1/3 times the maximum size of the coarse aggregate, nor less than one inch.

B. Where reinforcement in beams or girders is placed in 2 or more layers, the clear distance between layers shall be not less than one inch.

C. In columns, the clear distance between longitudinal bars shall be not less than 1-1/2 times the bar diameter, nor less than 1-1/2 times the maximum size of the coarse aggregate, nor less than 1-1/2 inches.

D. The clear distance between bars shall also apply to the distance between a contact splice and adjacent splices or bars.

3.5 SPLICING

A. General

1. Reinforcement bar splices shall only be used at indicated locations.

2. When it is necessary to splice reinforcement at points other than where indicated, the character of the splice shall be as reviewed and accepted by the ENGINEER.

3. Unless otherwise indicated, dowels shall match the size and spacing of the spliced bar.

B. Splices of Reinforcement

1. The length of lap for reinforcement bars, unless otherwise indicated, shall be in accordance with ACI 318 for a Class B splice.

2. Welded Wire Reinforcement

a. Laps of welded wire reinforcement shall be in accordance with ACI 318.

b. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet.

c. Wires shall be staggered and tied in such a manner that they cannot slip.

3. Splices in column spiral reinforcement, when necessary, shall be made by welding or by a lap of 1-1/2 turns.

C. Bending or Straightening

1. Reinforcement shall not be straightened or re-bent in a manner which will injure the material.

2. Bars shall be bent or straight as indicated.

3. Do not use bends different from the bends indicated.

4. Bars shall be bent cold, unless otherwise permitted by the ENGINEER.

5. No bars partially embedded in concrete shall be field-bent except as indicated or specifically permitted by the ENGINEER.

D. Couplers

1. Couplers that are located at a joint face shall be of a type that can be set either flush or recessed from the face as indicated.

2. The couplers shall be sealed during concrete placement to completely eliminate concrete or cement paste from entering.

3. Couplers intended for future connections shall be recessed a minimum of 1/2 inch from the concrete surface.

4. After the concrete is placed, the coupler shall be plugged with plastic plugs which have an O-ring seal and the recess filled with sealant to prevent any contact with water or other corrosive materials.

5. Threaded couplers shall be plugged .

E. Unless indicated otherwise, mechanical coupler spacing and capacity shall match the spacing and capacity of the reinforcing indicated for the adjacent section.

3.6 CLEANING AND PROTECTION

A. Reinforcement steel shall always be protected from conditions conducive to corrosion until concrete has been placed around it.

B. The surfaces of reinforcement steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed.

C. Where there is delay in depositing concrete, the reinforcement shall be re-inspected and, if necessary, re-cleaned.

3.7 EMBEDMENT OF DRILLED REINFORCING STEEL DOWELS

A. Hole Preparation

1. The hole diameter shall be as recommended by the epoxy manufacturer but shall be no larger than 1/4 inch greater than the diameter of the outer surface of the reinforcing bar deformations.

2. The depth of the hole shall be as recommended by the epoxy manufacturer to fully develop the bar but shall not be less than 12 bar diameters, unless indicated otherwise.

3. The hole shall be drilled by methods that do not interfere with the proper bonding of epoxy.

4. Existing reinforcing steel in the vicinity of proposed holes shall be located prior to drilling, and the location of holes shall be adjusted to avoid drilling through or nicking any existing reinforcing bars.

5. The hole shall be blown clean with clean, dry compressed air to remove dust and loose particles.

B. Embedment

1. Epoxy shall be injected into the hole through a tube placed to the bottom of the hole.

2. The tube shall be withdrawn as epoxy is placed but kept immersed to prevent formation of air pockets.

3. The hole shall be filled to a depth that insures excess material will be expelled from the hole during dowel placement.

4. Dowels shall be twisted during insertion into the partially filled hole so as to guarantee full wetting of the bar surface with epoxy.

5. The bar shall be inserted slowly enough to avoid developing air pockets.

END OF SECTION

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SECTION 03 31 00 - CAST-IN-PLACE CONCRETE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide cast-in-place concrete, as indicated in accordance with the Contract Documents.

B. The following types of concrete are covered in this Section:

1. Structural Concrete

a. Regular Mix: Roof, floor slabs, columns, walls, pavements, and other concrete items not indicated otherwise in the Contract Documents.

b. Thick Section Mix: For 12-inch and thicker walls, slabs on grade, pavements, and footings. This type of concrete may be used at the indicated locations at the CONTRACTOR's option if the ENGINEER agrees.

c. Congested Section Mix: Use where indicated or at the Contractor's option if approved by the Engineer.

d. Pea Gravel Mix: Required at the bottom 6 inches of walls with waterstops.

e. Sitework Concrete: Concrete to be used for curbs, gutters, catch basins, sidewalks, fence and guard post embedment, underground duct bank encasement, and other concrete appurtenant to electrical facilities, unless otherwise indicated.

f. Lean Concrete

1) Concrete to be used for thrust blocks, pipe trench cut-off blocks, and cradles that are indicated as unreinforced

2) Lean concrete shall be used as protective cover for dowels intended for future connections.

C. The term "hydraulic structure" shall mean environmental engineering concrete structures for the containment, treatment, or transmission of water, wastewater, other fluids, or gases, and may be dry or wet environment.

1.2 CONTRACTOR SUBMITTALS

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

B. Mix Designs

1. Prior to beginning the WORK and within 14 Days of the Notice to Proceed, submit preliminary concrete mix designs which shall show the proportions and gradations of materials proposed for each class and type of concrete.

2. Mix designs shall be checked through trial batch and laboratory testing by an independent testing laboratory acceptable to the ENGINEER.

3. Costs related to trial batch and related laboratory testing shall be CONTRACTOR’s responsibility as part of the WORK.

4. Since laboratory trial batches require 35 calendar days to complete, the CONTRACTOR shall test a minimum of 2 mix designs for each class of concrete.

C. Delivery Tickets

1. Where ready-mix concrete is used, the CONTRACTOR shall furnish delivery tickets at the time of delivery of each load of concrete.

2. Each ticket shall show the state-certified equipment used for measuring and the total quantities, by weight, of cement, sand, each class of aggregate, admixtures, the amount of water in the aggregate added at the batching plant, and the amount allowed to be added at the Site for the specific design mix.

3. In addition, each ticket shall state the mix number, total yield in cubic yards, and the time of day, to the nearest minute, corresponding to the times when the batch was dispatched, when it left the plant, when it arrived at the Site, when unloading began, and when unloading was finished.

D. Test Data: Test data relating to the cement, aggregate, and admixtures shall be less than 6 months old.

E. Furnish the following submittals in accordance with ACI 301 – Structural Concrete:

1. mill tests for cement

2. admixture certification, including chloride ion content

3. aggregate gradation test results and certification

4. materials and methods for curing

1.3 CONCRETE CONFERENCE

A. The ENGINEER will chair a meeting to review the detailed requirements of the CONTRACTOR's proposed concrete design mixes and to determine the procedures for producing proper concrete construction no later than 14 Days after the Notice to Proceed.

B. Parties involved in the concrete WORK shall attend the conference, including the following at a minimum:

1. CONTRACTOR's representative

2. testing laboratory representative

3. concrete subcontractor

4. reinforcing steel subcontractor and detailer

5. concrete supplier

6. admixture manufacturer's representative

C. The conference shall be held at a time and place proposed by the CONTRACTOR and accepted by the ENGINEER.

D. The conference shall be held at least 5 Days after acceptance.

1.4 QUALITY ASSURANCE

A. General

1. Tests on component materials and for compressive strength and shrinkage of concrete shall be performed as indicated.

2. Tests for determining slump shall be in accordance with ASTM C 143 – Test Method for Slump of Hydraulic Cement Concrete.

3. Testing for aggregate shall include sand equivalence, reactivity, organic impurities, abrasion resistance, and soundness, according to ASTM C 33 – Concrete Aggregates.

4. The cost of trial batch laboratory tests on cement, aggregates, and concrete shall be the CONTRACTOR's responsibility.

5. The cost of laboratory tests on field-placed cement, aggregates, and concrete and the cost of Special Inspections required by Code will be the OWNER'S responsibility.

6. The CONTRACTOR shall be responsible for the cost of any tests and investigations of WORK that is determined to be Defective WORK.

7. The testing laboratory shall meet or exceed ASTM C 1077 – Practice for Laboratories Testing Concrete and Concrete Aggregates for use in Construction and Criteria for Laboratory Evaluation.

8. Concrete for testing shall be furnished by the CONTRACTOR, and the CONTRACTOR shall assist the ENGINEER in obtaining samples and disposal and cleanup of excess material.

B. Inspections

1. Continuous inspection by a special inspector approved by the local building department having jurisdiction and by the ENGINEER will be required where necessary to conform with Code requirements.

2. Costs of the special inspector shall be paid by the OWNER.

3. Inspection reports shall be submitted to the ENGINEER.

4. The special inspector shall observe the following for conformance to the Contract Documents:

a. the preparation and taking of required test specimens; and,

b. placement of concrete, except sitework concrete fully supported on earth; and,

c. all other special inspection items listed within Contract Structural Drawings.

C. Field Compression Tests

1. Compression test specimens shall be taken during construction from the first placement of each type of concrete and at intervals thereafter as selected by the ENGINEER to insure continued compliance with the Specifications.

2. Each set of specimens shall be a minimum of 5 cylinders.

3. Compression test specimens for concrete shall be made in accordance with Section 9.2 of ASTM C 31 – Practices for Making and Curing Concrete Test Specimens in the Field.

4. Specimens shall be 6-inches diameter by 12-inches tall cylinders.

5. Compression tests shall be performed in accordance with ASTM C 39 – Test Method for Compressive Strength of Cylindrical Concrete Specimens.

6. One test cylinder shall be tested at 7 Days, and 2 test cylinders tested at 28 Days.

7. The remaining cylinders shall be held to verify test results, if needed.

D. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be in accordance with ACI 318 – Building Code Requirements for Reinforced Concrete, Chapter 5 "Concrete Quality," and as indicated.

2. A statistical analysis of compression test results shall be performed according to ACI 214 – Recommended Practice for Evaluation of Strength Test Methods.

3. The standard deviation of the test results shall not exceed 640 psi, when ordered at equivalent water content as estimated by slump.

4. If any concrete fails to meet these requirements, immediate corrective action shall be taken to increase the compressive strength for subsequent batches of the type of concrete affected.

5. When the standard deviation of the test results exceeds 640 psi, the average strength for which the mix is designed shall be increased by an amount necessary to satisfy the statistical requirement that the probability of any test being more than 500 psi below or the average of any 3 consecutive tests being below the required compressive strength is 1 in 100.

6. The required average strength shall be calculated by Criterion No. 3 of ACI 214 using the actual standard deviation.

7. Concrete that fails to meet the ACI requirements and the indicated requirements is subject to removal and replacement.

E. Shrinkage Tests

1. Drying shrinkage tests shall be performed for the trial batches indicated in the Article below entitled "Trial Batch and Laboratory Tests," for the first placement of each class of structural concrete except pea gravel mix, and during placement to determine continued compliance.

2. Neither structural pea gravel nor structural C-R pea gravel mix need to be tested for shrinkage.

3. Drying shrinkage specimens shall be 4-inch by 4-inch by 11-inch prisms with an effective gauge length of 10-inches, and fabricated, cured, dried, and measured in accordance with ASTM C 157 – Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete, modified as follows:

   a. Specimens shall be removed from molds at an age of 23 hours, plus or minus one hour, after trial batching, and shall be placed immediately in water at 70 degrees F, plus or minus 3 degrees F, for at least 30 minutes.

   b. Specimens shall be measured within 30 minutes thereafter to determine original length and then shall be submerged in saturated lime water at 73 degrees F, plus or minus 3 degrees F.

   c. Measurement to determine expansion expressed as a percentage of original length shall be made at age 7 Days.

   d. This length at age 7 Days shall be the base length for drying shrinkage calculations ("0" days drying age).

   e. Specimens then shall be stored immediately in a humidity control room maintained at 73 degrees F, plus or minus 3 degrees F, and 50 percent relative humidity, plus or minus 4 percent, for the remainder of the test.

   f. Measurements to determine shrinkage, expressed as percentage of base length, shall be performed and reported separately for 7, 14, 21, and 28 Days of drying after 7 Days of moist curing.

4. The drying shrinkage deformation of each specimen shall be computed as the difference between the base length (at "0" days drying age) and the length after drying at each test age.

5. The average drying shrinkage deformation of the specimens shall be computed to the nearest 0.0001 inch at each test age.

6. If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004 inch, the results obtained from that specimen shall be disregarded.

7. Results of the shrinkage test shall be reported to the nearest 0.001 percent of shrinkage.

8. Compression test specimens shall be taken in each case from the same concrete used for preparing drying shrinkage specimens.

9. These tests shall be considered a part of the normal compression tests for the project.

10. Allowable shrinkage limitations are indicated in PART 2 - PRODUCTS, below.

F. Aggregate Testing: Aggregate testing shall be performed for the trial batch in the Article below entitled “Trial Batch and Laboratory Tests” prior to construction and every 12 months during construction to determine continued compliance.

G. Construction Tolerances

1. The CONTRACTOR shall set and maintain concrete forms and perform finishing operations to ensure that the completed WORK is within tolerances.

2. Surface defects and irregularities are defined as finishes and are different from tolerances.

3. Tolerance is the permissible variation from lines, grades, or dimensions indicated on the Drawings.

4. Where tolerances are not indicated, permissible deviations shall be in accordance with ACI 117 – Standard Tolerance for Concrete Construction and Materials.

5. The following non-cumulative construction tolerances apply to finished walls, columns and slabs unless otherwise indicated:

ITEM	TOLERANCE
Variation of the constructed linear outline from the established position in plan.	in 10 feet: 1/4 inch in 20 feet or more: 1/2 inch
Variation from the level or from the grades indicated.	in 10 feet: 1/4 inch in 20 feet or more: 1/2 inch
Variation from plumb	in 10 feet: 1/4 inch in 20 feet or more: 1/2 inch
Variation in the thickness of slabs and walls.	minus 1/4 inch plus 1/2 inch
Variation in the locations and sizes of slabs and wall openings	plus or minus 1/4 inch

PART 2 -- PRODUCTS

2.1 CONCRETE MATERIALS

A. General

1. Concrete materials in contact with potable water shall be classified as acceptable for potable water use in accordance with NSF/ANSI Standard 61 as required by the authority having jurisdiction. Not all products listed herein are for use in contact with potable water.

2. Cement for concrete that will contact potable water shall not be obtained from kilns that burn metal rich hazardous waste fuel.

3. Materials shall be delivered, stored, and handled so as to prevent damage by water or breakage.

4. Cement reclaimed from cleaning bags or leaking containers shall not be used.

5. Cement shall be used in the sequence of receipt of shipments.

B. Materials and storage of materials shall comply with ACI 301, as applicable

C. Materials for concrete shall conform to the following requirements:

1. Cement

    a. Cement shall be standard brand Portland cement conforming to ASTM C 150 – Portland Cement, for Type II or Type V.

    b. A minimum of 85 percent of cement by weight shall pass a 325 screen.

    c. A single brand of cement shall be used throughout the WORK, and prior to its use, the brand shall be accepted by the ENGINEER.

    d. The cement shall be suitably protected from exposure to moisture until used.

    e. Cement that has become lumpy shall not be used.

    f. Sacked cement shall be stored in such a manner so as to permit access for inspection and sampling.

    g. Certified mill test reports, including fineness, for each shipment of cement to be used shall be submitted to the ENGINEER, if requested, regarding compliance with the Specifications.

2. Water

    a. Water for mixing and curing shall be potable, clean, and free from objectionable quantities of silty organic matter, alkali, salts, and other impurities.

    b. The water shall be considered potable, for the purposes of this Section only, if it meets the requirements of the local governmental agencies.

    c. Agricultural water with high total dissolved solids (greater than 1000 mg/L TDS) shall not be used.

3. Aggregates

    a. Aggregates shall be obtained from pits acceptable to the ENGINEER, shall be non-reactive, and shall conform to ASTM C 33 – Concrete Aggregates.

    b. The maximum size of coarse aggregate shall be as indicated, and the substitution of lightweight sand for fine aggregate will not be permitted.

    c. Coarse Aggregates

        1) Coarse aggregates shall consist of clean, hard, durable gravel, crushed gravel, crushed rock, or a combination thereof.

        2) The coarse aggregates shall be prepared and handled in 2 or more size groups for combined aggregates, with a maximum size greater than 3/4 inch.

        3) When the aggregates are proportioned for each batch of concrete, the 2 size groups shall be combined (also refer to the Article below entitled "Trial Batch and Laboratory Tests").

    d. Fine Aggregates

1) Fine aggregates shall be natural sand or a combination of natural and manufactured sand that is hard and durable.

2) When tested in accordance with ASTM D 2419 – Test Methods for Sand Equivalent Value of Soils and Fine Aggregate, the sand equivalency shall not be less than 75 percent for an average of 3 samples, nor less than 70 percent for an individual test.

3) The gradation of fine aggregate shall conform to ASTM C 33 when tested in accordance with ASTM C 136 for the fineness modulus of the sand used, including the optional grading in Section 6.2.

4) The fineness modulus of sand used shall not be greater than 3.1.

5) When tested in accordance with ASTM C 33, the fine aggregate shall produce a color in the supernatant liquid no darker than the reference standard color solution.

e. Combined Aggregates

1) Combined aggregates shall be well graded from coarse to fine sizes and shall be uniformly graded between screen sizes to produce concrete that has optimum workability and consolidation characteristics.

2) Where a trial batch is required for a mix design, the final combined aggregate gradations will be established during the trial batch process.

3) When tested in accordance with ASTM C 33, the coarse aggregate shall show a loss not exceeding 42 percent after 500 revolutions or 10.5 percent after 100 revolutions.

f. When tested in accordance with ASTM C 33, the ratio of silica released to reduction in alkalinity shall not exceed 1.0.

g. When tested in accordance with ASTM C 33, the loss resulting after 5 cycles of the soundness test shall not exceed 10 percent for fine aggregate and 12 percent for coarse aggregate when using sodium sulfate.

4. Ready-mixed concrete shall conform to the requirements of ASTM C 94 – Ready Mixed Concrete.

5. Admixtures

a. Admixtures shall be compatible and shall be furnished by a single manufacturer capable of providing qualified field service representation.

b. Admixtures shall be used in accordance with manufacturer's recommendations.

c. If the use of an admixture is producing an inferior end result, the CONTRACTOR shall discontinue use of the admixture.

d. Admixtures shall not contain thiocyanates nor more than 0.05 percent chloride ion, and shall be non-toxic after 30 days.

e. Air Content

1) An air-entraining agent meeting the requirements of ASTM C 260 – Air Entraining Admixtures for Concrete shall be used.

2) The OWNER reserves the right, at any time, to sample and test the air-entraining agent.

3) The air-entraining agent shall be added to the batch in a portion of the mixing water.

4) The solution shall be batched by means of a mechanical batcher capable of accurate measurement.

5) Air content shall be tested at the point of placement.

6) The air entraining agent shall be Micro-Air by Master Builders; Daravair by W.R. Grace; Sika AEA-15 by Sika Corporation; or equal

f. Set-Controlling and Water-Reducing Admixtures

1) Admixtures may be added at the CONTRACTOR's option, subject to the ENGINEER's approval, to control the set, effect water reduction, and increase workability.

2) The cost of adding an admixture shall be the CONTRACTOR's responsibility.

3) Concrete containing an admixture shall be first placed at a location determined by the ENGINEER.

4) Admixtures shall conform to ASTM C 494 – Chemical Admixtures for Concrete.

5) The required quantity of cement shall be used in the mix regardless of whether or not an admixture is used.

6) Concrete shall not contain more than one water-reducing admixture, unless it can be demonstrated that the proposed mix will meet the indicated drying shrinkage requirements.

7) The set-controlling admixture may be either with or without water-reducing properties.

8) Where the air temperature at the time of placement is expected to be consistently greater than 80 degrees F, a set-retarding admixture such as **Plastocrete 161MR by Sika Corporation**, **Pozzolith or Delvo** by **BASF**, **Daratard** by **W.R. Grace**, or equal shall be used.

9) Where the air temperature at the time of placement is expected to be consistently less than 40 degrees F, a non-corrosive set accelerating admixture such as **Plastocrete 161FL** by **Sika Corporation**, **MasterSet FP 20** by **BASF**, **Daraset** by **W.R. Grace**, or equal shall be used.

10) Mid-Range Water Reducers

a) General use water-reducing admixtures shall be mid-range and shall conform to ASTM C 494, Type A and F.

b) Use Daracem by **W.R. Grace, Polyheed** by **BASF**, **Sikament** by **Sika Corporation**, or equal.

c) The quantity of admixture used and the method of mixing shall be in accordance with the manufacturer's instructions and recommendations.

11) High-Range Water Reducers

a) High-range water reducers shall conform to ASTM C 494, Type F or G.

b) Use **ADVA** by **W.R. Grace**, **ViscoCrete** by **Sika Corporation**, **Glenium** by **BASF**, or equal.

c) The high-range water reducer shall be added to the concrete after all other ingredients have been mixed and initial slump has been verified.

d) No more than 14 ounces of water reducer per sack of cement shall be used.

e) The water reducer shall be considered as part of the mixing water when calculating the water/cement ratio.

f) If the high-range water reducer is added to the concrete at the Site, it may be used in conjunction with the same water reducer added at the batch plant.

g) Concrete shall have a slump of 3 inches, plus or minus 1/2 inch, prior to adding the high-range water reducing admixture at the Site.

h) The high-range water reducing admixture shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician.

i) A standby system shall be provided and tested prior to each day's operation of the primary system.

j) Concrete shall be mixed at mixing speed for a minimum of 70 mixer revolutions or 5 minutes after the addition of the high-range water reducer, unless recommended otherwise by the manufacturer.

g. Other Admixtures

1) Flyash

a) Flyash shall not be used for concrete sections in hydraulic structures.

b) For other concrete, fly ash may be substituted for not more than 15 percent, by weight, of cement in structural concrete and not more than 30 percent, by weight, for sitework concrete, and not more than 50 percent, by weight, of cement in other concrete.

c) Fly ash shall conform to ASTM C618 and shall not have loss-on-ignition greater than 3 percent.

d) The water/cement ratio shall be calculated based on cement plus fly ash.

2) Ground Blast Furnace Slag Cement

a) Slag cement shall not be used for concrete sections in hydraulic structures.

b) Slag cement shall conform to ASTM C989 – Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars, Grade 100 or 120.

c) Blended cements shall conform to ASTM C595 – Blended Hydraulic Cements, Type 1S, or ASTM C1157 – Performance Specification for Hydraulic Cement.

d) Slag cement substitution, if used, shall be not less than 25, nor more than 50 percent by weight of cement.

e) Slag cement substitution shall not be used with fly ash substitution.

f) The water/cement ratio shall be calculated based on cement plus slag cement.

3) Fiber reinforcing

a) Fiber-reinforced concrete shall be furnished where indicated.

b) Fiber reinforcement shall be synthetic fiber reinforcement.

c) Use **Fibermesh 300**, as manufactured by **Propex**, or equal.

d) Fiber reinforcing shall be batched at the plant at a rate of 1.5 pounds per cubic yard of concrete.

e) Material: 100-percent virgin homopolymer polypropylene-fibrillated fibers; containing no reprocessed olefin materials

f) Conformance: ASTM C 1116, Type III

g) Fire Classifications: UL Report File No. R8534-11; Southwest Certification Services (SWCS), Omega Point Laboratories No. 8662-1

h) Fiber Length: one inch

i) Alkali Resistance: alkali-proof

j) Absorption: nil

k) Specific Gravity: 0.91

l) Melting Point: 324 degrees F (162 degrees C)

2.2 CURING MATERIALS

A. General: Curing compounds shall be resin-based and shall be compliant with local VOC requirements, unless otherwise indicated herein.

B. Regular Curing Compound

1. Regular curing compound shall be white-pigmented and shall conform to ASTM C 309 - Liquid Membrane-Forming Compounds for Curing Concrete, Type 2, Class B.

2. Sodium silicate compounds will not be accepted.

3. The concrete curing compound shall be:

a. Kurez VOX White Pigmented by Euclid Chemicals Company;

b. L&M Cure R-2 by L&M Construction Chemicals;

c. 1200-White by W.R. Meadows;

d. Kure-N-Seal WB White Pigmented by Sonneborn/Degussa Building Systems;

e. or equal.

C. Dissipating Curing Compound

1. When the curing compound must be removed for finishes or grouting, compounds shall be of a dissipating type, conforming to ASTM C 309, Type 1 or 2, Class B.

2. The dissipating curing compound shall be:

a. Korez DR VOX by Euclid Chemical Company;

b. L&M Cure R-2 by L & M Construction Chemicals;

c. 1100-Clear by W.R. Meadows;

d. or equal.

D. Curing Compound for Applications Requiring NSF/ANSI Standard 61 Compliance

1. When the curing compound is required to conform to NSF/ANSI Standard 61, the curing compound shall be water-based and shall be compliant with all local VOC requirements; shall conform to ASTM C 309; and shall be certified to conform to the requirements of NSF/ANSI Standard 61.

2. The NSF/ANSI Standard 61 Certified curing compound shall be:

a. E-Cure by SpecChem, LLC;

b. Atlas Quantum-Cure NSF by Atlas Tech Products;

c. or equal.

E. Concrete Curing Blanket

1. Polyethylene Sheets

    a. Polyethylene sheets for use as concrete curing blanket shall be white and shall have a nominal thickness of 6 mils.

    b. The loss of moisture when determined in accordance with ASTM C 156 – Test Method for Water Retention by Concrete Curing Materials, shall not exceed 0.055 grams per square centimeter of surface.

2. Polyethylene-Coated Waterproof Paper

    a. Polyethylene-coated waterproof paper sheeting for use as concrete curing blanket shall consist of white polyethylene sheeting free of visible defects, uniform in appearance, shall have a nominal thickness of 2-mils, and shall be permanently bonded to waterproof paper conforming to the requirements of Federal Specification UU-B-790A – Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellant and Fire Resistant).

    b. The loss of moisture, when determined in accordance with ASTM C 156, shall not exceed 0.055 gram per square centimeter of surface.

3. Polyethylene-Coated Burlap

    a. Polyethylene-coated burlap for use as concrete curing blanket shall be 4 mils thick, with white opaque polyethylene film impregnated or extruded into one side of the burlap.

    b. The burlap shall weigh not less than 9 ounces per square yard.

    c. The loss of moisture, when determined in accordance with ASTM C 156, shall not exceed 0.055 grams per square centimeter of surface.

F. Curing Mats

1. Curing mats for use in Curing Method 6, below, shall be heavy shag rugs or carpets or cotton mats quilted at 4 inches on center.

2. Curing mats shall weigh a minimum of 12 ounces per square yard when dry.

G. Evaporation Retardant

1. An evaporation retardant shall be used.

2. The evaporation retardant shall be:

    a. MasterKure ER 50 by BASF/Master Builders;

    b. Eucobar by Euclid Chemical Company;

    c. E-CON by L & M Construction Chemicals, Inc.;

    d. or equal.

2.3 NON-WATERSTOP JOINT MATERIALS

A. Materials for non-waterstop joints in concrete shall conform to the following requirements:

1. The preformed joint filler shall be a non-extruding neoprene sponge or polyurethane type conforming to Section 03 32 00 – Joints in Concrete.

2. The elastomeric joint sealer shall conform to ASTM C 920 – Standard Specification for Elastomeric Joint Sealants.

3. Mastic Joint Sealer

a. The mastic joint sealer shall be a material:

1) that does not contain evaporating solvents;

2) that will tenaciously adhere to concrete surfaces;

3) that will remain permanently resilient and pliable;

4) that will not be affected by the continuous presence of water;

5) that will not in any way contaminate potable water;

6) and that will effectively seal the joints against moisture infiltration even when the joints are subject to movement from expansion and contraction.

b. The sealer shall be composed of special asphalts or similar materials blended with lubricating and plasticizing agents to form a tough, durable mastic substance containing no volatile oils or lubricants.

c. The sealer shall be capable of meeting the indicated test requirements, if testing is required by the ENGINEER.

2.4 MISCELLANEOUS MATERIALS

A. Damproofing Agent

1. The damproofing agent shall be an asbestos-free, fibered asphalt emulsion intended for cold application to green concrete, both above- and below-grade.

2. Damproofing shall meet the requirements of ASTM D 1227 – Emulsified Asphalt Used as a Protective Coating for Roofing, Type II, Class I.

3. Dampproofing shall be:

a. Hydrocide 700 Series by Sonneborn/Degussa Building Systems;

b. Sealmastic by W. R. Meadows;

c. HE 789 by Henry Company;

d. or equal.

B. Bonding Agents

1. Bonding agents shall be epoxy adhesives.

2. Bonding agents for bonding freshly-mixed, plastic concrete to hardened concrete shall be:

    a. Sikadur 32 Hi-Mod Epoxy Adhesive by Sika Corporation;

    b. MasterEmaco ADH 326 by BASF/Master Builders;

    c. BurkEpoxy MV by Edoco;

    d. or equal.

3. Bonding agents for bonding hardened concrete or masonry to steel shall be:

    a. Sikadur 31 Hi-Mod Gel by Sika Corporation;

    b. BurkEpoxy NS by Edoco;

    c. Concresive Paste (LPL) by MBT/Degussa Building Systems;

    d. or equal.

C. Colorant for duct bank concrete shall be an integral red oxide coloring pigment used in the proportion of 8 pounds per cubic yard of concrete.

2.5 CONCRETE DESIGN REQUIREMENTS

A. General

1. Concrete shall be composed of cement, admixtures, aggregates, and water of the qualities indicated.

2. The exact proportions in which these materials are to be used for different parts of the WORK shall be determined during the trial batches.

3. In general, the mix shall be designed to produce a concrete capable of being deposited to obtain maximum density and minimum shrinkage, and, where deposited in forms, to have good consolidation properties and maximum smoothness of surface.

4. The aggregate gradations shall be formulated to provide fresh concrete that will not promote rock pockets around reinforcing steel or embedded items.

5. The proportions shall be changed whenever necessary or desirable to meet the required results, and such changes shall be subject to review by the ENGINEER.

B. Fine Aggregate Composition

1. In mix designs for structural concrete, except for 1/2-inch and 3/8-inch maximum size aggregate, the percentage of fine aggregate in total aggregate by weight shall be as indicated in the following table:

FINE AGGREGATE	
Fineness Modulus	Percent (maximum)
2.7 or less	41
2.7 to 2.8	42
2.8 to 2.9	43
2.9 to 3.1	44

2. For other concrete, the maximum percentage of fine aggregate of total aggregate by weight shall not exceed 50 percent.

C. Duct Bank Concrete

1. Duct bank concrete shall contain an integral red-oxide coloring pigment.

2. The concrete shall be dyed red throughout.

3. Using a surface treatment to color duct banks will not be accepted.

D. Water/Cement Ratio

1. The indicated water/cement ratio is for a saturated-surface dry condition of aggregate.

2. Throughout every Day, the added batch water shall be adjusted for the total free water in the aggregates, which shall be determined as follows:

   a. The total moisture content of all aggregate shall be calculated by ASTM C 566 – Test Method for Total Moisture Content of Aggregate by Drying.

   b. Subtract the moisture absorbed by the coarse aggregate, calculated by ASTM C 127 – Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate.

   c. Subtract the moisture absorbed by the fine aggregate, calculated by ASTM C 128 – Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Fine Aggregate.

E. Concrete Property Tables

1. The maximum cement contents, maximum W/C Ratios and maximum Water Contents given in the Concrete Property Tables below are intended to minimize drying shrinkage and heat of hydration of the concrete.

2. It is understood that the indicated maximum cement contents and maximum water contents may require additional water reducing agent for the workability required by the CONTRACTOR'S methods, and may not result in the least costly concrete mix for the required concrete strength.

STRUCTURAL CONCRETE				
Type of WORK	Regular Mix (roof, floor slabs, walls, pavements, and other concrete items not categorized elsewhere)	Thick Section Mix (12-inch and thicker walls, slabs on grade, pavements, and footings)	Congested Section Mix (Use where indicated or at the CONTRACTOR's option and if approved by the ENGINEER)	Pea Gravel Mix (concrete at the bottom 6 inches of waterstopped walls) At the CONTRACTOR's option, superplastic Regular Mix may be substituted for the first lift
Min 28 Day Compressive Strength, psi	4500	4500	5000	5000
Max Aggregate Size, in	1	1-1/2	1/2	3/8
Cementious material content per cubic yard, lb, minimum	564	564	600	658
Cementious material content per cubic yard, lb, maximum	658	658	658	752
Water content per cubic yard, lb, maximum	254	254	240	301
Max W/C Ratio by weight	0.42	0.42	0.40	0.40
Total Air Content, percent	3 to 6	3 to 6	3 to 6	4.5 to 7.5
Slump	4 inches +/- 1 in with high-range water reducer: 7 inches +/- 2 in	4 inches +/- 1 in with high-range water reducer: 7 inches +/- 2 in	with high-range water reducer: 7 inches +/- 2 in	with high-range water reducer: 7 inches +/- 2 in

Type of WORK	Sitework Concrete (curbs, gutters, sidewalks, catch basins, fence embedments, encasements, and ductbanks)	Lean Concrete (thrust blocks, pipe trench cut-off blocks, and cradles)
Min 28 Day Compressive Strength, psi	3000	2000
Max Aggregate Size, in	1	1
Cement Content per cubic yard, lb, minimum	470	376
Water content per cubic yard, lb, maximum	254	270
Max W/C Ratio by weight	0.45	0.60
Total Air Content, percent	3 to 6	3 to 6
Slump	4 inches +/- 1 in ductbanks and encasements: 5 inches +/- 1 in	4 inches +/- 1 in

NOTE: The CONTRACTOR is cautioned that the limiting parameters above are not a mix design. Admixtures may be required to achieve workability required by the CONTRACTOR's construction methods and aggregates. The CONTRACTOR shall be responsible for providing concrete with the required workability and strength.

F. Adjustments to Mix Design

1. The CONTRACTOR may elect to decrease the water/cement ratio to achieve the strength and shrinkage requirements and/or add water reducers, as required to achieve workability.

2. The mixes shall be changed whenever such change is necessary or desirable to secure the required strength, density, workability, and surface finish, and the CONTRACTOR shall be entitled to no additional compensation because of such changes.

3. Any changes to the accepted concrete mix design shall be submitted to the ENGINEER for review and shall be tested again in accordance with the indicated requirements.

2.6 CONSISTENCY

A. The quantity of water in a batch of concrete shall be just sufficient, with a normal mixing period, to produce a concrete that can be worked properly into place without segregation and which can be compacted by vibratory methods to give the desired density, impermeability, and smoothness of surface.

B. The quantity of water shall be changed as necessary, with variations in the nature or moisture content of the aggregates, in order to maintain uniform production of a desired consistency.

C. The consistency of the concrete in successive batches shall be determined by slump tests in accordance with ASTM C 143 – Test Method for Slump of Hydraulic Cement Concrete.

D. The slumps shall be as indicated with the concrete properties.

2.7 TRIAL BATCH AND LABORATORY TESTS

A. The CONTRACTOR shall only use a mix design for construction that has first met the trial batch testing requirements.

B. Before placing any concrete, a testing laboratory selected by the ENGINEER shall prepare a trial batch of each class of structural concrete, based on the preliminary concrete mixes submitted by the CONTRACTOR.

C. Aggregate Proportions

1. During the trial batch the aggregate proportions may be adjusted by the testing laboratory using the two coarse aggregate size ranges to obtain the required properties.

2. If one size range produces an acceptable mix, a second size range need not be used.

3. Such adjustments will be considered refinements to the mix design and will not be the basis for extra compensation to the CONTRACTOR.

4. Concrete shall conform to the indicated requirements whether the aggregate proportions are from the CONTRACTOR's preliminary mix design or whether the proportions have been adjusted during the trial batch process.

5. The trial batch shall be prepared using the aggregates, cement, and admixture proposed for the project.

D. The trial batch materials shall be of a quantity such that the testing laboratory can obtain 3 drying shrinkage and 6 compression test specimens from each batch.

E. The determination of compressive strength shall be made by testing 6-inch diameter by 12-inch high cylinders, which have been made, cured, and tested in accordance with ASTM C 192 – Practice for Making and Curing Concrete Test Specimens in the Laboratory, and ASTM C 39.

F. The testing schedule shall be 3 compression test cylinders tested at 7 Days and 3 at 28 Days.

G. The average compressive strength for the 3 cylinders tested at 28 Days for any given trial batch shall be not less than 125 percent of the indicated compressive strength.

H. A sieve analysis of the combined aggregate for each trial batch shall be performed according to the requirements of ASTM C 136 – Method for Sieve Analysis of Fine and Coarse Aggregates, and values shall be provided for percent passing each sieve.

2.8 SHRINKAGE LIMITATION

A. General

1. The CONTRACTOR shall only use a mix design for construction that has first met the trial batch shrinkage requirements.

2. Shrinkage limitations shall apply only to structural concrete.

B. Maximum Shrinkage

1. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-Day drying age or at 28-Day drying age, shall be 0.036 percent or 0.042 percent, respectively.

2. Standard deviation will not be considered.

3. The maximum concrete shrinkage for specimens cast in the field shall not exceed the trial batch maximum shrinkage requirement by more than 25 percent.

C. If the required shrinkage limitation is not met during construction, the CONTRACTOR shall take any or all of the following actions to reestablish compliance:

1. changing the source of aggregates, cement and/or admixtures;

2. reducing water/cement ratio;

3. washing of coarse and/or fine aggregate to reduce fines;

4. increasing the number of construction joints;

5. modifying the curing requirements; or

6. other actions to minimize shrinkage or the effects of shrinkage.

2.9 MEASUREMENT OF CEMENT AND AGGREGATE

A. The amount of cement and of each separate size of aggregate entering into each batch of concrete shall be determined by direct weighing equipment furnished by the CONTRACTOR and acceptable to the ENGINEER.

B. Weighing Tolerances

Material	Percent of Total Weight
Cement	1
Aggregates	3
Admixtures	3

2.10 MEASUREMENT OF WATER

A. The quantity of water entering the mixer shall be measured by a suitable water meter or other measuring device of a type acceptable to the ENGINEER and capable of measuring the water in variable amounts within a tolerance of one percent.

B. The water feed control mechanism shall be capable of being locked in position in order to constantly deliver the required amount of water to each batch of concrete.

C. A positive, quick-acting valve shall be used for a cut-off in the water line to the mixer, and the operating mechanism shall prevent leakage when the valve is closed.

2.11 READY-MIXED CONCRETE

A. General

1. At the CONTRACTOR'S option, ready-mixed concrete may be used if it meets the indicated requirements as to materials, batching, mixing, transporting and placement, and is in accordance with ASTM C 94 and the following supplementary requirements.

2. Ready-mixed concrete shall be delivered to the WORK, and discharge shall be completed within one hour after the addition of the cement to the aggregates or before the drum has been revolved 250 revolutions, whichever occurs first.

3. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted.

4. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted.

5. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the ENGINEER.

B. Counters

1. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified.

2. The counter shall be of the resettable, recording type and shall be mounted in the driver's cab.

3. The counters shall be actuated at the time of starting the mixers at mixing speeds.

C. Mixing

1. Each batch of concrete shall be mixed in a truck mixer for not less than 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment.

2. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed.

3. Materials, including the mixing water, shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.

D. Uniformity

1. Truck mixers and their operation shall be such that the concrete throughout the mixed batch as discharged is within acceptable limits of uniformity with respect to consistency, mix, and grading.

2. If slump tests taken at approximately the 1/4- and 3/4-point of the load during discharge result in slumps differing by more than one inch when the required slump is 3 inches or less, or if they differ by more than 2 inches when the required slump is more than 3 inches, the mixer shall not be used on the WORK unless the causative condition is corrected and satisfactory performance is verified by additional slump tests.

3. Mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit, and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.

E. Each batch of ready-mixed concrete delivered to the Site shall be accompanied by a delivery ticket that is furnished to the ENGINEER in accordance with the Paragraph in Part 1 of this Section entitled "Delivery Tickets."

PART 3 -- EXECUTION

3.1 PROPORTIONING AND MIXING

A. Proportioning of the mix shall conform to ACI 301.

B. Mixing shall conform to ACI 301.

C. Slumps shall be as indicated.

D. Re-tempering of concrete or mortar that has partially hardened will not be permitted.

3.2 PREPARATION OF SURFACES FOR CONCRETING

A. General

1. Earth surfaces shall be thoroughly wetted by sprinkling prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon.

2. The surface shall be free from standing water, mud, and debris at the time of placing concrete.

B. Joints in Concrete

1. Construction joints are defined as concrete surfaces upon which or against which concrete is to be placed, but placement of concrete has been stopped or interrupted and the ENGINEER has determined that the new concrete cannot be incorporated integrally with the concrete previously placed.

2. The surfaces of horizontal joints shall be given a compacted, roughened surface for good bonding.

3. Except where coated joint surfaces have been indicated, the joint surfaces shall be cleaned of laitance, loose or defective concrete, foreign material, and be roughened to a minimum 1/4-inch amplitude.

4. Cleaning and roughening shall be accomplished by hydroblasting or sandblasting (exposing aggregate) followed by thorough washing.

5. Pools of water shall be removed from the surface of construction joints before the new concrete is placed.

6. Gravel

a. After the surfaces have been prepared, each approximately horizontal construction joint shall be covered with a 6-inch lift of a pea gravel mix.

b. The gravel mix shall be placed and spread uniformly.

c. Wall concrete shall follow immediately and shall be placed upon the fresh pea gravel mix.

C. Placement Interruptions

1. When placing of concrete is to be interrupted long enough for the concrete to take a set, the working face shall be given a shape by the use of forms or other means that will secure proper union with subsequent WORK.

2. Such construction joints shall be made only where acceptable to the ENGINEER.

D. Embedded Items

1. No concrete shall be placed until the formwork, the installation of parts to be embedded, the reinforcement steel, and the preparation of surfaces involved in the placing have been completed and accepted by the ENGINEER at least 4 hours before the placement of concrete.

2. Surfaces of forms and embedded items that have become encrusted with dried grout from previous usage shall be cleaned before the surrounding or adjacent concrete is placed.

3. Inserts or other embedded items shall conform to the indicated requirements.

4. Reinforcement, anchor bolts, sleeves, inserts, and similar items shall be set and secured in the forms at locations as indicated or shown by Shop Drawings, and shall be acceptable to the ENGINEER before any concrete is placed.

5. Accuracy of placement shall be the responsibility of the CONTRACTOR.

E. Casting New Concrete Against Old Concrete

1. Where concrete is to be cast against old concrete (defined as any concrete which is greater than 60 Days old), the surface of the old concrete shall be thoroughly cleaned and roughened by hydroblasting or sandblasting to expose aggregate.

2. The joint surface shall be coated with an epoxy bonding agent unless determined otherwise by the ENGINEER.

F. Water

1. No concrete shall be placed in any structure until water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes or other means, and carried out of the forms, clear of the WORK.

2. No concrete shall be deposited underwater nor shall the CONTRACTOR allow still water to rise on any concrete until the concrete has attained its initial set.

3. Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as will injure the surface finish of the concrete.

4. Pumping or other necessary dewatering operations for removing ground water, if required, shall be subject to review by the ENGINEER.

G. Corrosion Protection

1. Pipe, conduit, dowels, and other ferrous items required to be embedded in concrete construction shall be positioned and supported prior to placement of concrete such that there will be a minimum of 2 inches clearance between said items and any part of the concrete reinforcement.

2. Securing such items in position by wiring or welding them to the reinforcement will not be permitted.

H. Openings for pipes, inserts for pipe hangers and brackets, and anchors shall be provided, where practicable, during the placement of concrete.

I. Anchor bolts shall be accurately set and shall be maintained in position by templates while embedded in the concrete.

J. Cleaning: The surfaces of metalwork to be in contact with the concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed.

3.3 HANDLING, TRANSPORTING, AND PLACING

A. General

1. The placement of concrete shall conform to the applicable portions of ACI 301 and the indicated requirements.

2. No aluminum materials shall be used in conveying any concrete.

B. Non-Conforming WORK or Materials

1. Concrete which during or before placing is found not to conform to the indicated requirements will be rejected and shall be immediately removed from the WORK.

2. Concrete that is not placed in accordance with these requirements or which is of inferior quality shall be removed and replaced.

C. Unauthorized Placement

1. No concrete shall be placed except in the presence of an authorized representative of the ENGINEER.

2. The CONTRACTOR shall notify the ENGINEER in writing at least 24 hours in advance of the placement of any concrete.

D. Placement in Wall and Column Forms

1. Concrete shall not be dropped through reinforcement steel or into any deep form, nor shall concrete be placed in any form in such a manner as to leave accumulation of mortar on the form surfaces above the placed concrete.

2. In such cases, means such as hoppers and, if necessary, vertical ducts of canvas, rubber, or metal shall be used for placing concrete in the forms in a manner that it may reach the place of final deposit without separation.

3. In no case shall the free fall of concrete below the ends of ducts, chutes, or buggies exceed 4 feet in walls and 8 feet in columns.

4. Concrete shall be uniformly distributed during the process of deposition, and in no case after deposition shall any portion be displaced in the forms more than 6 feet in the horizontal direction.

5. Concrete in wall forms shall be deposited in uniform horizontal layers not deeper than 2 feet, and care shall be exercised to avoid inclined layers or inclined construction joints except where such are required for sloping members.

6. Each layer shall be placed while the previous layer is still soft.

7. The rate of placing concrete in wall forms shall not exceed 5 feet of vertical rise per hour.

8. Sufficient illumination shall be provided in the interior of forms such that the concrete at the places of deposit is visible from the deck or runway.

E. Casting New Concrete Against Old

1. An epoxy adhesive bonding agent shall be applied to the old surfaces according to the manufacturer's written recommendations.

2. This provision shall not apply to joints where waterstop has been provided.

3. Refer to Section 03 32 00 – Joints in Concrete, for other requirements.

F. Conveyor Belts and Chutes

1. Ends of chutes, hopper gates, and other points of concrete discharge throughout the CONTRACTOR's conveying, hoisting, and placement system shall be designed and arranged such that concrete passing from them will not fall separated into whatever receptacle immediately receives it.

2. Conveyor belts, if used, shall be of a type acceptable to the ENGINEER.

3. Chutes longer than 50 feet will not be permitted.

4. The minimum slopes of chutes shall be such that concrete of the indicated consistency will readily flow in them.

5. If a conveyor belt is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt will be wasted.

6. Conveyor belts and chutes shall be covered.

G. Placement in Slabs

1. Concrete placement in sloping slabs shall proceed uniformly from the bottom of the slab to the top for the full width of the placement.

2. As the WORK progresses, the concrete shall be vibrated and carefully worked around the slab reinforcement, and the surface of the slab shall be screeded in an up-slope direction.

H. Temperature of Concrete

1. The temperature of concrete when it is being placed shall be not more than 90 degrees F nor less than 50 degrees F.

2. For sections less than 12 inches thick, the temperature of concrete when placed shall be not less than 55 degrees F.

I. Hot or Cold Weather Procedures

1. If required by the ENGINEER, the CONTRACTOR shall submit detailed procedures for the production, transportation, placement, protection, curing, and temperature monitoring of concrete during hot or cold weather.

2. The submittal shall include procedures to be implemented upon abrupt changes in weather conditions or equipment failures.

3. The CONTRACTOR shall not be entitled to additional compensation for satisfying the hot weather placement or the cold weather placement requirements below.

J. Hot Weather Placement

1. If the temperature of the concrete is 85 degrees F or greater, the time between introducing the cement into the aggregates and discharge shall not exceed 45 minutes.

2. If the concrete is placed when the weather is such that the temperature of the concrete would exceed 90 degrees F, the CONTRACTOR shall employ effective means such as pre-cooling of aggregates, using ice as mixing water, or placing at night as necessary to maintain the temperature of the concrete below 90 degrees F as it is placed.

3. During the curing period, the maximum temperature decrease measured at the surface of the concrete shall not exceed 50 degrees F in 24 hours nor 5 degrees F in one hour.

K. Cold Weather Placement

1. The placement of concrete shall conform to ACI 306.1 – Cold Weather Concreting, and the following requirements:

a. Remove snow, ice, and frost from the surfaces, including reinforcement, against which concrete is to be placed.

b. Before beginning concrete placement, thaw the subgrade to a minimum depth of 6 inches.

c. Reinforcement and embedded items shall be warmed to above 32 degrees F prior to concrete placement.

d. Maintain the concrete temperature above 50 degrees F for at least 72 hours after placement.

e. Concrete ingredients shall not be heated more than necessary to prevent the temperature of the mixed concrete, as placed, from falling below the minimum temperature criterion.

3.4 PUMPING OF CONCRETE

A. General: If the pumped concrete does not produce satisfactory end results, the CONTRACTOR shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.

B. Pumping Equipment

1. The pumping equipment shall have 2 cylinders and shall be designed to operate with one cylinder in case the other one is not functioning.

2. In lieu of this requirement, the CONTRACTOR may have a standby pump on the Site during pumping.

3. The minimum diameter of the hose conduits shall be in accordance with ACI 304.2R – Placing Concrete by Pumping Methods.

4. Pumping equipment and hose conduits that are not functioning properly shall be replaced.

5. Aluminum conduits for conveying the concrete will not be permitted.

C. Field Control: Concrete samples for slump, air content, and test cylinders shall be taken at the placement end of the hose.

3.5 ORDER OF PLACING CONCRETE

A. General

1. The order of placing concrete in the WORK shall be acceptable to the ENGINEER.

2. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints at the indicated locations.

B. The placing of units shall be done by placing alternate units in a manner such that each unit placed shall have cured at least 2 Days for all structures before the contiguous unit or units are placed, except that the corner sections of vertical walls shall not be placed until the 2 adjacent wall panels have cured at least 4 Days for all structures.

C. Concrete Surfaces

1. The surface of the concrete shall be level whenever a run of concrete is stopped.

2. For a level, straight, intermediate joint on the exposed surface of walls, a wood strip at least 3/4-inch thick shall be tacked to the forms on these surfaces.

3. The concrete shall be carried approximately 1/2 inch above the underside of the strip.

4. The strip shall be removed one hour after the concrete is placed, and any irregularities in the edge formed by the strip shall be leveled with a trowel and laitance shall be removed.

3.6 TAMPING AND VIBRATING

A. As concrete is placed in the forms or in excavations, it shall be thoroughly settled and compacted throughout the entire depth of the layer which is being consolidated, into a dense and homogeneous mass, filling all corners and angles, thoroughly embedding the reinforcement, eliminating rock pockets, and bringing only a slight excess of water to the exposed surface of concrete.

B. Vibrators

1. Vibrators shall be Group 3 in accordance with ACI 309 – Consolidation of Concrete, high speed power vibrators (8000 to 12,000 rpm) of an immersion type in sufficient number and with at least one standby unit as required.

2. Group 2 vibrators may be used only at specific locations when accepted by the ENGINEER.

C. Waterstops

1. Care shall be exercised when placing concrete around waterstops.

2. The concrete shall be carefully worked by rodding and vibrating to make sure that air and rock pockets have been eliminated.

3. Where flat-strip type waterstops have been placed horizontally, the concrete shall be worked under the waterstops by hand, making sure that air and rock pockets have been eliminated.

4. Concrete that is surrounding the waterstops shall be given additional vibration over and above that used for adjacent concrete placement to ensure complete embedment of the waterstops in the concrete.

D. Concrete in Walls

1. Concrete in walls shall be internally vibrated and at the same time rammed, stirred, or worked with suitable appliances, tamping bars, shovels, or forked tools until it completely fills the forms or excavations and closes snugly against each surface.

2. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly.

3. Vibrators shall be provided in sufficient numbers, with standby units as required, to accomplish the required results within 15 minutes after concrete of the prescribed consistency has been placed in the forms.

4. The vibrating head shall not contact the surfaces of the forms.

5. Care shall be exercised not to vibrate concrete excessively or to work it in any manner that causes segregation of its constituents.

3.7 FINISHING CONCRETE SURFACES

A. General

1. Concrete surfaces shall be free from fins, bulges, ridges, offsets, honeycombing, or roughness of any kind, and shall present a finished, smooth, continuous hard surface.

2. Allowable deviations from plumb or level and from the alignment, profiles, and dimensions are defined as tolerances and shall be as indicated.

3. These tolerances are to be distinguished from irregularities in finish as indicated.

4. Aluminum finishing tools shall not be used.

B. Formed Surfaces

1. No treatment shall be required after form removal except for curing, repair of defective concrete, and treatment of surface defects.

2. Surface holes larger than 1/2 inch in diameter or deeper than 1/4 inch are defined as surface defects in basins and exposed walls.

C. Unformed Surfaces

1. General

a. After proper and adequate vibration and tamping, unformed top surfaces of slabs, floors, walls, and curbs shall be brought to a uniform surface with suitable tools.

b. Immediately after the concrete has been screeded it shall be treated with a liquid evaporation retardant, and the retardant shall be used again after each operation as necessary to prevent drying shrinkage cracks.

2. The classes of finish for unformed concrete surfaces are defined as follows:

a. Finish U1

1) Sufficient leveling and screeding to produce an even, uniform surface with surface irregularities not to exceed 3/8 inch.

2) No further special finish is required.

b. Finish U2

1) After sufficient stiffening of the screeded concrete, surfaces shall be float finished with wood or metal floats or with a finishing machine using float blades.

2) Excessive floating of surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture will not be permitted.

3) Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture.

4) Surface irregularities shall not exceed 1/4 inch.

5) Joints and edges shall be tooled where indicated or as determined by the ENGINEER.

c. Finish U3

1) After the Finish U2 surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface free from blemishes, ripples, and trowel marks.

2) The finish shall be smooth and free of irregularities.

d. Finish U4

1) Trowel the Finish U3 surface to remove local depressions or high points.

2) In addition, the surface shall be given a light broom finish with brooming perpendicular to drainage unless otherwise indicated.

3) The resulting surface shall be sufficiently rough to provide a nonskid finish.

e. Unformed surfaces shall be finished according to the following schedule:

UNFORMED SURFACE FINISH SCHEDULE	
Area	Finish
grade slabs and foundations to be covered with concrete or fill material	U1
slabs not water bearing	U4
top surface of walls	U3

3.8 CURING AND DAMPPROOFING

A. General: Concrete shall be cured for not less than 7 Days after placement, in accordance with the methods indicated below for the different parts of the WORK.

Surface to be Cured or Dampproofed	Method
unstripped forms	1
construction joints between footings and walls, and between floor slab and columns	2
encasement and ductbank concrete and thrust blocks	3
concrete surfaces not specifically indicated in this Paragraph	4
slabs not on grade	5
wall sections with forms removed	5

B. Method 1

1. Wooden forms shall be wetted immediately after concrete has been placed and shall be kept wet with water until removal.

2. If steel forms are used the exposed concrete surfaces shall be kept continuously wet until the forms are removed.

3. If forms are removed within 7 Days of placing the concrete, curing shall be continued in accordance with Method 5, below.

C. Method 2

1. The surface shall be covered with burlap mats which shall be kept wet with water for the duration of the curing period, until the concrete in the walls has been placed.

2. No curing compound shall be applied to surfaces cured under Method 2.

D. Method 3

1. The surface shall be covered with moist earth not less than 4 hours nor more than 24 hours after the concrete is placed.

2. Earthwork operations that may damage the concrete shall not begin until at least 7 Days after placement of the concrete.

E. Method 4

1. The surface shall be sprayed with a liquid curing compound.

2. The compound shall be applied in accordance with the manufacturer's printed instructions at a maximum coverage rate of 200 square feet per gallon and in such a manner as to cover the surface with a uniform film that will seal thoroughly.

3. Seal Protection

a. Where the curing compound method is used, care shall be exercised to avoid damage to the seal during the 7-Day curing period.

b. If the seal is damaged or broken before expiration of the curing period, the break shall be repaired immediately by the application of additional curing compound over the damaged portion.

4. Wherever curing compound has been applied by mistake to surfaces against which concrete subsequently is to be placed and to which it is to adhere, such compound shall be entirely removed by wet sandblasting just prior to the placing of new concrete.

5. Application Schedule

a. The curing compound shall be applied as soon as the concrete has hardened enough to prevent marring on unformed surfaces and within 2 hours after removal of forms.

b. Repairs to formed surfaces shall be made within the 2 hour period; provided, however, that any such repairs which cannot be made within the said 2 hour period shall be delayed until after the curing compound has been applied.

c. When repairs are to be made to an area on which curing compound has been applied, the area involved shall first be wet-sandblasted to remove the curing compound.

6. At locations where concrete is placed adjacent to a panel which has been coated with curing compound, the panel shall have curing compound reapplied to an area within 6 feet of the joint and to any other location where the curing membrane has been disturbed.

7. Prior to final acceptance of the WORK, visible traces of curing compound shall be removed in such a manner that does not damage the surface finish.

F. Method 5

1. Method 5 shall apply to both walls and slabs.

2. The concrete shall be kept continuously wet by the application of water for a minimum period of at least 7 Days, beginning immediately after the concrete has reached final set or the forms have been removed.

3. Until the concrete surface is covered with the curing mats, the entire surface shall be kept damp by applying water using nozzles that atomize the flow such that the surface is not marred or washed.

4. Curing Mats

   a. Heavy curing mats shall be used as a curing medium to retain the moisture during the curing period.

   b. The curing mats shall be weighted or otherwise held substantially in contact with the concrete surface to prevent dislodging by wind or other causes.

   c. Edges shall be continuously held in place.

5. The curing mats and concrete shall be kept continuously wet by the use of sprinklers or other means both during and after normal working hours.

6. Immediately after the application of water has terminated at the end of the curing period, the curing mats shall be removed, the entire concrete surface shall be wetted, and curing compound shall be immediately applied to the entire surface in accordance with Method 4, above.

7. The CONTRACTOR shall dispose of excess water from the curing operation in order to avoid damage to the WORK.

3.9 PROTECTION

A. The CONTRACTOR shall protect the concrete against damage until final acceptance.

B. Weather Protection

1. Fresh concrete shall be protected from damage due to rain, hail, sleet or snow.

2. The CONTRACTOR shall provide such protection while the concrete is still plastic and whenever precipitation is imminent or occurring.

3.10 CURING DURING COLD WEATHER

A. Water curing of concrete may be reduced to 6 Days during periods when the mean daily temperature in the vicinity of the Site is less than 40 degrees F, provided that during the prescribed period of water curing, when temperatures are such that concrete surfaces may freeze, water curing has been temporarily discontinued.

B. Compound-Cured Concrete

1. Concrete that is to be cured by an application of curing compound shall require no additional protection from freezing if the protection at 50 degrees F for 72 hours is obtained by means of approved insulation in contact with the forms or concrete surfaces.

2. Otherwise, the concrete shall be protected against freezing temperatures for 72 hours immediately following 72 hours protection at 50 degrees F.

C. Concrete cured by water shall be protected against freezing temperatures for 72 hours immediately following the 72 hours of protection at 50 degrees F.

D. Discontinuance of Protection

1. Discontinuance of protection against freezing temperatures shall be such that the drop in temperature of any portion of the concrete will be gradual and will not exceed 40 degrees F in 24 hours.

2. In the spring, when the mean daily temperature rises above 40 degrees F for more than 3 successive Days, the required 72-hour protection at a temperature not lower than 50 degrees F may be discontinued for as long as the mean daily temperature remains above 40 degrees F, provided that the concrete shall be protected against freezing temperatures for not less than 48 hours after placement.

E. Artificial Heat

1. Where artificial heat is employed, special care shall be taken to prevent the concrete from drying.

2. The use of unvented heaters will be permitted only when unformed surfaces of concrete adjacent to the heaters are protected for the first 24 hours from an excessive carbon dioxide atmosphere by application of curing compound, provided that the use of curing compound for such surfaces is otherwise permitted.

3.11 TREATMENT OF SURFACE DEFECTS

A. General

1. Surface defects are defined in Finishing Concrete Surfaces, above.

2. As soon as forms are removed, the exposed concrete surfaces shall be carefully examined and any irregularities shall be immediately rubbed or ground in order to secure a smooth, uniform, and continuous surface satisfactory to the Engineer.

3. Plastering or coating of surfaces to be smoothed will not be permitted.

4. No repairs shall be made until after inspection by the ENGINEER.

5. In no case will extensive patching of honeycombed concrete be permitted.

6. Concrete containing minor voids, holes, honeycombing, or similar depression defects shall be repaired as indicated below.

7. Concrete containing extensive voids, holes, honeycombing, or similar depression defects shall be completely removed and replaced..

8. Repairs of surface defects shall be performed promptly.

B. Preparation

1. Defective surfaces to be repaired shall be cut back from trueline a minimum depth of 1/2-inch over the entire area.

2. Feathered edges will not be permitted.

3. Where chipping or cutting tools are not required in order to deepen the area properly, the surface shall be prepared for bonding by the removal of laitance and soft material,

plus not less than 1/32-inch depth of the surface film from hard portions by means of an efficient sandblast.

4. After cutting and sandblasting, the surface shall be wetted sufficiently in advance of shooting with shotcrete or with cement mortar such that while the repair material is being applied the surfaces underneath will remain moist but not so wet as to overcome the suction upon which a good bond depends.

C. Materials

1. The material used for repair shall consist of a mixture of one sack of cement to 3 cubic feet of sand.

2. For exposed walls, the cement shall contain such a proportion of Atlas White Portland cement as is required to make the color of the patch match the color of the surrounding concrete.

D. Holes

1. Holes left by tie-rod cones shall be reamed with suitably toothed reamers in order to leave the surfaces of the holes clean and rough.

2. Holes then shall be repaired in an approved manner with dry-packed cement grout.

3. Holes left by form-tying devices having a rectangular cross section and other imperfections having a depth greater than their least surface dimension shall not be reamed but shall be repaired in an approved manner with dry-packed cement grout.

E. Repairs

1. Repairs shall be built up and shaped in such a manner that the completed WORK will conform to the indicated requirements, using approved methods which will not disturb the bond, cause sagging, or cause horizontal fractures.

2. The surfaces of repaired concrete shall receive the same kind and amount of curing treatment as required for the concrete in the repaired section.

3.12 CONCRETE REPAIR AND REHABILITATION

A. All defects and repairs not covered under Treatment of Surface Defects shall be repaired per Section 03 01 30 - Concrete Repair and Rehabilitation.

3.13 CARE AND REPAIR OF CONCRETE

A. The CONTRACTOR shall protect concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until Final Acceptance.

B. Particular care shall be exercised in order to prevent the drying shrinkage damage of concrete and to avoid roughening or otherwise damaging the concrete surface.

C. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed WORK, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be repaired or removed and replaced with acceptable materials to the satisfaction of the ENGINEER.

END OF SECTION

SECTION 03 32 00 - JOINTS IN CONCRETE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide joints in concrete, complete and in place, in accordance with the Contract Documents.

B. Joints in concrete structures shall be the types defined below and will be permitted only where indicated, unless specifically accepted by the ENGINEER.

1.2 TYPES OF JOINTS

A. Construction Joints

1. When fresh concrete is placed against a hardened concrete surface, the joint between the pours shall be defined as a construction joint.

2. Unless otherwise indicated, joints in water-bearing members shall be provided with a waterstop and/or sealant groove of the shape indicated.

B. Contraction Joints

1. Contraction joints are similar to construction joints except that the fresh concrete shall not bond to the hardened surface of the earlier pour.

2. The slab reinforcement shall be stopped 4-1/2 inches from the joint; which is provided with a sleeve-type dowel, in order to allow shrinkage of the concrete of the later pour.

3. Waterstop and/or sealant groove shall be provided where indicated.

C. Expansion Joints

1. In order to allow the concrete to expand freely, a space shall be provided between the 2 pours, and the joint shall be formed as indicated.

2. The space shall be obtained by placing a filler joint material against the earlier pour to act as a form for the later pour.

3. Unless otherwise indicated, expansion joints in water bearing members shall be provided with a center-bulb type waterstop.

4. Provide premolded expansion joint material with the edge at the indicated distance below or back from the finished concrete surface.

5. Provide a slightly tapered, dressed and oiled wooden strip secured to or placed at the edge of the expansion joint during concrete placement, and remove the strip later to form a space for the sealing material.

6. The space so formed shall be filled with a joint sealant material as indicated below. In order to keep the 2 wall or slab elements in line, the joint shall also be provided with a sleeve-type dowel as indicated.

D. Control Joints

1. The function of the control joint is to provide a weaker plane in the concrete where shrinkage cracks would likely occur.

2. Formed Groove

a. A groove, of the shape and dimensions indicated, shall be formed or saw-cut in the concrete and the groove shall then be filled with a joint sealant material.

b. The formed groove shall be placed in the first of the two sections cast at the control joint, in order to assure that the sealant bonds to the second section across the joint and not to the cement paste from the first pour.

1.3 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Furnish placement drawings showing the location and types of joints for each structure.

2. Test Reports

a. Furnish certified test reports from the sealant manufacturer on the actual batch of material supplied, demonstrating compliance with the indicated requirements.

b. Furnish the test reports before using the sealant on the Project.

3. Welding Certification

a. Furnish copies of the waterstop welding certification by manufacturer or authorized agent of the manufacturer.

b. Every person who is to be involved with waterstop installation shall be required to have individual certification on file with the ENGINEER, stating that the named individual is certified and trained to install waterstop in accordance with the manufacturer’s recommendations and specifications.

4. Joint Sealant Installation Certification

a. Furnish copies of the joint sealant installation certification by manufacturer or authorized agent of the manufacturer.

b. Every person who is to be involved with joint sealant installation shall be required to have individual certification on file with the ENGINEER, stating that the named individual is certified and trained to install joint sealant in accordance with the manufacturer’s recommendations and specifications.

5. Furnish manufacturer's information demonstrating compliance of the following with the indicated requirements:

    a. bearing pad

    b. neoprene sponge

    c. preformed joint filler

    d. backing rod

    e. waterstop

    f. slip dowels

    g. PVC tubing

C. Samples

1. Prior to production of the material required under this Section, submit qualification samples of waterstops which accurately represent the material being provided.

2. Such samples shall be extruded or molded sections of each size or shape to be installed.

3. The balance of the material to be used shall not be produced until after the ENGINEER has reviewed the qualification samples.

D. Certificates

1. Furnish written certification from the manufacturer, as an integral part of the shipping form, that the material shipped to the Site meets or exceeds the indicated physical property requirements.

2. Supplier certificates will not be accepted.

1.4 QUALITY ASSURANCE

A. Waterstop Inspection

1. Waterstop field joints shall be subject to inspection, and no such WORK shall be scheduled or started without having made prior arrangements with the ENGINEER for the required inspections.

2. Provide not less than 24 hours notice for the scheduling of such inspections.

3. Field joints in waterstops shall be subject to inspection for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects that would reduce the potential resistance of the material to water pressure at any point.

4. Defective field joints shall be replaced with material that passes inspection, and faulty material shall be removed from the Site and destroyed.

B. The following waterstop defects represent a partial list of defects which shall be grounds for rejection:

1. offsets at joints greater than 1/16 inch or 15 percent of material thickness at any point, whichever is less

2. exterior cracking at the joint due to incomplete bond, which is deeper than 1/16 inch or 15 percent of material thickness at any point, whichever is less

3. any combination of offset or exterior cracking that will result in a net reduction in the cross-section of the waterstop in excess of 1/16 inch or 15 percent of material thickness at any point, whichever is less

4. misalignment of the joint which results in misalignment of the waterstop in excess of 1/2 inch in 10 feet

5. porosity in the welded joint as evidenced by visual inspection

6. bubbles or inadequate bonding which can be detected with a penknife test. (If, while prodding the entire joint with the point of a penknife, the knife breaks through the outer portion of the weld into a bubble, the joint shall be considered defective.)

7. visible signs of separation when the cooled splice is bent by hand at any sharp angle

8. evidence of burned material

C. Waterstop Samples

1. Prior to use of the waterstop material in the field, a sample of a prefabricated (shop made fitting) mitered cross and a tee constructed of each size or shape of material to be used shall be submitted.

2. Samples shall be prefabricated (shop made fitting) so that the material and workmanship represent the fittings to be provided.

3. In addition, field samples of prefabricated fittings (crosses, tees, and the like) will be selected at random by the ENGINEER for testing by a laboratory at the OWNER's expense.

4. When tested, the tensile strength across the joints shall be at least 1120 psi for PVC waterstops.

D. Construction Joint Sealant

1. The CONTRACTOR shall prepare adhesion and cohesion test specimens at intervals of 5 Days while sealants are being installed.

2. The sealant material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:

a. Sealant specimen shall be prepared between 2 concrete blocks (1-inch by 2-inch by 3-inch).

b. Spacing between the blocks shall be one inch.

c. Coated spacers (2-inch by 1-1/2-inch by 1/2-inch) shall be used to set and hold sealant cross-sections of 1/2-inch by 2-inch with a width of one inch.

d. The sealant shall be cast and cured in accordance with the manufacturer's recommendations, except that the curing period shall be not less than 24 hours.

e. Following the curing period, the gap between the blocks shall be widened to 1-1/2 inches, and spacers shall be used to maintain this gap for 24 hours prior to inspection for failure.

1.5 SPECIAL CORRECTION OF DEFECTS REQUIREMENT

A. The CONTRACTOR shall furnish a 5-year written warranty of the entire sealant installation against faulty and/or incompatible materials and workmanship, together with a statement that the CONTRACTOR agrees to repair or replace, to the satisfaction of the OWNER, any defective areas which become evident within the 5-year period.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Joint materials shall be listed as compliant with NSF Standard 61.

2.2 WATERSTOPS

A. PVC Waterstops

1. Waterstops shall be extruded from an elastomeric polyvinyl chloride compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the indicated requirements of this Section.

2. No reclaimed or scrap material shall be used.

3. The CONTRACTOR shall obtain from the waterstop manufacturer and shall furnish to the ENGINEER for review, current test reports and a written certification of the manufacturer that the material to be shipped to the Site meets the physical requirements as outlined in the U.S. Army Corps of Engineers Specification CRD-C572-PVC Waterstops, and those indicated.

4. Flatstrip and Center-Bulb Waterstops

a. Flatstrip and center-bulb waterstops shall be manufactured such that at no place shall the thickness of waterstops, including the center bulb type, be less than 3/8 inch.

b. The waterstop shall be provided with hog rings installed at 12 inches on centers along the waterstop.

c. Shapes shall be as indicated, or as acceptable to the ENGINEER.

5. Multi-Rib Waterstops

    a. Multi-rib waterstops shall be as indicated or as acceptable to the ENGINEER.

    b. Prefabricated joint fittings shall be used at intersections of the ribbed-type waterstops.

6. Retrofit Waterstops

    a. Retrofit waterstops and batten bars shall be as indicated or as acceptable to the ENGINEER.

    b. The waterstop shall be supplied as a complete system including waterstop, SS batten bar, SS anchor bolts, and epoxy gel.

7. When tested in accordance with the indicated test standards, the waterstop material shall meet or exceed the following requirements:

Physical Property, Sheet Material	Value	ASTM Std
Tensile Strength-min, psi	2000	D 638, Type IV
Ultimate Elongation-min, percent	350	D 638, Type IV
Low Temp Brittleness, max degrees F	-35	D 746
Stiffness in Flexure, min, psi	600	D 747
Accelerated Extraction (CRD-C572		
Tensile Strength-min, psi	1500	D 638, Type IV
Ultimate Elongation, min, percent	300	D 638, Type IV
Effect of Alkalies (CRD-C572		
Change in Weight, percent	plus 0.25/minus 0.10	------
Change in Durometer, Shore A	plus and minus 5	D 2240
Finish Waterstop		
Tensile Strength-min, psi	1400	D 638, Type IV
Ultimate Elongation, min percent	280	D 638, Type IV

B. Preformed Hydrophilic Waterstop

1. Hydrophilic (bentonite-free) waterstops shall be Hydro-Flex Waterstop as manufactured by Henry Co., or Earthshield Type 20, as manufactured by JP Specialties, or equal.

2. The cross-sectional area of the waterstop shall not be less than 0.5 square inch.

3. Hydrophilic waterstop shall be the type that expands in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.

4. The waterstop shall be manufactured from butyl rubber with hydrophilic properties.

5. The waterstop shall have a delay coating to inhibit initial expansion due to moisture present in fresh concrete.

6. The minimum expansion ratio of modified chloroprene shall be not less than 2-to-1 volumetric change in distilled water at 70 degrees F (21 degrees C).

7. The bonding agent for hydrophilic waterstop shall be the manufacturer's recommended adhesive for wet, rough concrete.

C. When types of waterstops not listed above are indicated, they shall be subjected to the same requirements as those listed in this Section.

2.3 JOINT SEALANT FOR WATER-BEARING JOINTS

A. The joint sealant shall be a polyurethane polymer designed for bonding to concrete which is continuously submerged in water.

B. No material will be accepted which has an unsatisfactory history as to bond or durability when used in the joints of water-retaining structures.

C. Joint sealant material shall meet the following requirements (73 degrees F and 5 percent R.H.):

Work Life, minutes	45 - 180
Time to Reach 20 Shore A Hardness (at 77 degrees F, 200 gram quantity), max	24 hours
Ultimate Hardness (ASTM D 2240, Shore A)	20 - 45
Tensile Strength (ASTM D 412), min	170 psi
Ultimate Elongation (ASTM D 412), minimum	400 percent
Tear Resistance (Die C, ASTM D 624), pounds per inch of thickness, min	75
Color	Light Gray

D. Polyurethane sealants for waterstop joints in concrete shall conform to the following requirements:

1. Sealant shall be 2-part polyurethane with the physical properties of the cured sealant conforming to or exceeding the requirements of ASTM C 920 – Elastomeric Joint Sealant, or Federal Specification TT-S-0227 E(3) - Sealing Compound, Elastomeric Type, Multicomponent, for Caulking, Sealing, and Glazing Buildings and Other Structures, for 2-part material, as applicable.

2. For vertical joints and overhead horizontal joints, only "non-sag" compounds shall be used, conforming to the requirements of ASTM C 920, Class 25, Grade NS, or Federal Specification TT-S-0227 E(3), Type II, Class A.

3. For plane horizontal joints, use the self-leveling compounds meeting the requirements of ASTM C 920 Class 25, Grade P, or Federal Specification TT-S-0227 E(3), Type I.

4. For joints subject to either pedestrian or vehicular traffic, a compound providing non-tracking characteristics and having a Shore A hardness range of 35 to 45 shall be used.

5. Primer materials, if recommended by the sealant manufacturer, shall conform to the printed recommendations of the manufacturer.

E. Sealant Manufacturers

1. Sealants shall be PSI-270 as manufactured by Polymeric Systems Inc., Sikaflex 2C, as manufactured by Sika Corporation, Pelseal (with Viton) 2112/2012, or equal.

2.4 JOINT MATERIALS

A. Bearing Pad

1. The bearing pad shall be neoprene conforming to ASTM D 2000 - Standard Classification System for Rubber Products in Automotive Applications, BC 420, 40 durometer hardness, unless otherwise indicated.

B. Neoprene Sponge

1. The sponge shall be neoprene, closed-cell, expanded, conforming to ASTM D 1056 - Flexible Cellular Materials - Sponge or Expanded Rubber, Type 2C5-E1.

C. Joint Filler

1. Joint filler for expansion joints in waterholding structures shall be neoprene conforming to ASTM D 1056, Type 2C5-E1.

2. Joint filler material in other locations shall be of the preformed non-extruding type, constructed of cellular neoprene sponge rubber or polyurethane of firm texture.

3. Bituminous fiber type will not be accepted.

4. Non-extruding and resilient-type preformed expansion joint fillers shall conform to the requirements and tests set forth in ASTM D 1752 - Preformed Sponge Rubber and

Cork Expansion Joint Fillers for Concrete Paving and Structural Construction, for Type I, except as otherwise indicated.

2.5 BACKING ROD

A. The backing rod shall be an extruded closed-cell, polyethylene foam rod.

B. The rod material shall be compatible with the joint sealant material, and shall have a tensile strength of not less than 40 psi and a compression deflection of approximately 25 percent at 8 psi.

C. The rod shall be 1/8 inch larger in diameter than the joint width except that a one-inch diameter rod shall be used for a 3/4-inch wide joint.

2.6 SLIP DOWELS

A. Slip dowels in joints shall be smooth epoxy-coated bars conforming to ASTM A 775 - Epoxy Coated Reinforcing Steel Bars.

2.7 PVC TUBING

A. PVC tubing in joints shall be SDR 13.5, conforming to ASTM D 2241 - Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

PART 3 -- EXECUTION

3.1 GENERAL

A. Waterstops shall be embedded in the concrete across joints as indicated.

B. Waterstops shall be fully continuous for the extent of the joint.

C. Splices necessary to provide such continuity shall conform to the printed instructions of the waterstop manufacturer.

D. The CONTRACTOR shall take suitable precautions and provide means to support and protect the waterstops during the progress of the WORK, and shall repair or replace any waterstops damaged during progress of the WORK at no additional cost to the OWNER.

E. Waterstops shall be stored so as to permit free circulation of air around the waterstop material.

F. When any waterstop is installed in the concrete on one side of a joint while the other portion of the waterstop remains exposed to the atmosphere for more than 2 Days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of the sun during the entire exposure time until the exposed portion of waterstop is embedded in concrete.

3.2 SPLICES IN PVC WATERSTOPS

A. Splices in PVC waterstops shall be performed by heat sealing the adjacent waterstop sections in accordance with the manufacturer's printed recommendations.

B. It is essential that:

1. The material shall not be damaged by heat sealing.

2. The splices shall have a tensile strength of not less than 80 percent of the unspliced material.

3. The continuity of the waterstop ribs and of its tubular center axis shall be maintained.

4. No edge welding will be accepted.

C. Butt joints of the ends of 2 identical waterstop sections may be made while the material is in the forms.

D. Other Joints

1. Joints with waterstops involving more than 2 ends to be jointed together, and joints that involve an angle cut, alignment change, or the joining of 2 dissimilar waterstop sections, shall be prefabricated prior to placement in the forms, allowing not less than 24-inch long strips of waterstop material beyond the joint.

2. Upon inspection and approval, such prefabricated waterstop joint assemblies shall be installed in the forms and the ends of the 24-inch strips shall be butt-welded to the straight run portions of waterstop in place in the forms.

E. Where a centerbulb waterstop intersects and is jointed with a non-centerbulb waterstop, care shall be taken to seal the end of the centerbulb, using additional PVC material if needed.

3.3 JOINT CONSTRUCTION

A. Setting Waterstops

1. In order to eliminate faulty installation that may result in joint leakage, particular care shall be taken as to the correct positioning of the waterstops during installation.

2. Adequate provisions shall be made to support and anchor the waterstops during the progress of the WORK and to ensure proper embedment in the concrete.

3. The symmetrical halves of the waterstops shall be equally divided between the concrete pours at the joints.

4. The center axis of the waterstops shall be coincident with the joint openings.

5. Thoroughly work the concrete in the vicinity of joints for maximum density and imperviousness.

B. Waterstop Placement

1. In placing waterstops in the forms, means shall be provided to prevent them from being folded over by the concrete as it is placed.

2. Waterstops shall be held in place with light wire ties on 12-inch centers, which shall be passed through hog rings at the edge of the waterstop and tied to the curtain of reinforcing steel.

3. Horizontal waterstops, with their flat face in a vertical plane, shall be held in place with continuous supports to which the top edge of the waterstop shall be tacked.

4. In placing concrete around horizontal waterstops with their flat face in a horizontal plane, the concrete shall be worked under the waterstops by hand in order to avoid the formation of air and rock pockets.

C. In placing centerbulb waterstops in expansion joints, the centerbulb shall be centered on the joint filler material.

D. Waterstop in vertical wall joints shall terminate 6 inches from the top of the wall, where such waterstop does not connect with any other waterstop and is not to be connected to a future concrete placement.

E. Joint Location

1. Construction joints and other types of joints shall be provided where indicated.

2. If not indicated, construction joints shall be provided at a 25-foot maximum spacing.

3. Where joints are indicated to be spaced greater than 40 feet apart, additional joints shall be provided to maintain the 25-foot maximum spacing.

4. The location of joints, regardless of type, shall be submitted for acceptance by the ENGINEER.

F. Joint Preparation

1. Special care shall be used in preparing concrete surfaces at joints where bonding between 2 sections of concrete is required.

2. Unless otherwise indicated, such bonding shall be required at every horizontal joint in walls.

3. Surfaces shall be prepared in accordance with Section 03 31 00 – Cast-in-Place Concrete.

G. Retrofit Joint Preparation

1. Existing surfaces to receive a retrofit waterstop shall be clean and free from any loose or foreign material.

2. The surface shall be given a light sandblast or hydroblast finish to 1/8-inch amplitude prior to the application of epoxy and waterstop.

H. Construction Joint Sealant

1. Construction joints in water-bearing floor slabs and elsewhere as indicated shall be provided with tapered grooves which shall be filled with a construction joint sealant.

2. The material used to form the tapered grooves shall be left in the grooves until just before the grooves are cleaned and filled with joint sealant.

3. After removing the forms from the grooves, laitance and fins shall be removed, and the grooves shall be sand blasted.

4. The grooves shall be allowed to thoroughly dry, after which they shall be blown out and immediately thereafter they shall be primed and filled with the construction joint sealant.

5. The primer shall be furnished by the sealant manufacturer, and no sealant shall be used without a primer.

6. Care shall be used to completely fill the sealant grooves.

7. Areas designated to receive a sealant fillet shall be thoroughly cleaned as outlined for the tapered grooves prior to application of the sealant.

I. The primer and sealant shall be placed strictly in accordance with the printed recommendations of the manufacturer, taking special care to properly mix the sealant prior to application.

J. The sides of the sealant groove shall not be coated with bond breaker, curing compound, or any other substance which would interfere with proper bonding of the sealant.

K. The sealant shall achieve final cure at least 7 Days before the structure is filled with water.

L. The sealant shall be installed by a worker certified by the sealant manufacturer.

M. Mixing

1. Catalyst-cured, 2-part materials shall be thoroughly and uniformly mixed, and special care shall be taken to properly mix the sealer before its application.

2. Before any sealer is placed, the CONTRACTOR shall arrange to have workers performing the WORK carefully instructed on the proper method of mixing and application by a representative of the sealant manufacturer.

N. Failure to Cure

1. Any joint sealant that fails to fully and properly cure after the manufacturer's recommended curing time for the conditions of the WORK shall be completely removed, and the groove shall be thoroughly sandblasted to remove traces of the uncured or partially cured sealant and primer.

2. The groove shall be re-sealed with the indicated joint sealant.

3. Costs of such removal, joint treatment, re-sealing, and appurtenant WORK shall be the CONTRACTOR’s responsibility as part of the WORK.

O. Hydrophilic Waterstop

1. Where a hydrophilic waterstop is indicated, it shall be installed in accordance with the manufacturer's instructions and recommendations except as may be modified in this Section.

2. When requested by the ENGINEER, the CONTRACTOR shall arrange for the manufacturer to furnish technical assistance in the field.

3. Hydrophilic waterstop shall only be used where complete confinement by concrete is provided.

4. Hydrophilic waterstop shall not be used in expansion or contraction joints nor in the first 6 inches of a non-intersecting joint.

5. Location

    a. The hydrophilic waterstop shall be located as near as possible to the center of the joint, and it shall be continuous around the entire joint.

    b. The minimum distance from the edge of the waterstop to the face of the member shall be 5 inches.

6. Placement

    a. Where the thickness of the concrete member to be placed on the hydrophilic waterstop is less than 12 inches, the waterstop shall be placed in grooves formed or ground into the concrete.

    b. The groove shall be at least 3/4 inch deep and 1-1/4 inches wide.

    c. When placed in the groove, the minimum distance from the edge of the waterstop to the face of the member shall be 2-1/2 inches.

7. Where a hydrophilic waterstop is used in combination with PVC waterstop, the hydrophilic waterstop shall overlap the PVC waterstop for a minimum of 6 inches and shall be adhered to PVC waterstop by a single component water-swelling sealant as recommended by the manufacturer.

8. The hydrophilic waterstop shall not be installed where the air temperature falls below the manufacturer's recommended range.

9. Preparation

    a. The concrete surface under the hydrophilic waterstop shall be smooth and uniform, and the concrete shall be ground smooth if needed.

    b. Alternatively, the hydrophilic waterstop shall be bonded to the surface using an epoxy grout that completely fills voids and irregularities beneath the waterstop material.

    c. Prior to installation, the concrete surface shall be wire brushed to remove any laitance or other materials that may interfere with the bonding of epoxy.

10. Securing

    a. The hydrophilic waterstop shall be secured in place with concrete nails and washers at 12-inch maximum spacing.

b. The above requirement shall be in addition to the adhesive recommended by the manufacturer.

P. Retrofit Waterstop

1. Retrofit waterstops shall be set in a bed of epoxy over a sandblasted surface with stainless steel batten bars and 1/4-inch diameter stainless steel anchors at 6 inches on-center, staggered, and in accordance with the manufacturer's written recommendations.

END OF SECTION

SECTION 03 34 00 – CELLULAR CONCRETE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide non-pervious closed cell, low density cellular concrete for backfilling in accordance with the details in the plans and these specifications.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

1. Mix design, including materials to be used and their sources.

2. Resume of contractor showing experiences as specified below, including qualifications of contractor's superintendent and/or foreman.

3. Description of equipment and placement procedures to verify compliance with specifications and assure the specified volumes are completely filled.

4. Drawings and supporting calculations showing the method of preventing pipe floatation, buckling, excessive deflection and damage.

5. Method statement and sequence of construction for placement of cellular concrete at locations indicated on the drawings and within this specification.

6. The mix design, drawings and supporting calculations shall be signed and stamped by a registered professional engineer in the State of Illinois.

1.3 QUALITY ASSURANCE

A. Contractor shall have a record of experience and quality of work placing cellular concrete that is satisfactory to the ENGINEER. Including the following:

1. Shall be capable of developing a mix design, batching, mixing, handling, and placing cellular concrete.

2. Shall be regularly engaged in the production and pumping of cellular concrete for tunnel backfilling.

3. Shall have satisfactory completed at least five (5) similar projects during the last three (3) years.

4. Workers, including the contractor's superintendent and /or foreman, shall be fully qualified to perform the work and have had previous experience in production and pumping of cellular concrete under similar conditions.

B. Field Tests

1. Field control tests, including unit weight (wet density), flow consistency, unconfined compression and permeability tests shall be performed by Contractor's independent laboratory. The independent laboratory shall have at least 5 years of experience in performing similar tests.

2. A minimum of four (4) 3”x 6” cylinders shall be molded for each shift of operation.

3. Cellular concrete may be tested at any age after three (3) days for compressive strength. At least two (2) specimens from each set should be tested at 28 days in accordance with ASTM C-495.

4. Measure flow consistency and unit weight (wet density) at the point of placement from the first batch mixed, every hour during the pour, and from each batch of cellular concrete from which compression test cylinders are made. Mix shall be adjusted as required to obtain the specified cast density at the point of placement.

PART 2 -- PRODUCTS

2.1 CELLULAR CONCRETE

A. General

1. Portland cement shall comply with ASTM C150 (Type III).

2. Fly ash shall be Class C or Class F and compatible with foaming agent.

3. Water shall be free from deleterious substances.

4. Foaming agent shall conform to ASTM C796.

5. Admixtures for water reducing, retarding, accelerating, and other specific properties may be used when recommended by the manufacturer of the foaming agent.

6. The cellular concrete shall have the following properties:

Cast Wet Density	75 pcf
Minimum Compressive Strength (28 Days)	2,000 psi
Flow Consistency per ASTM D6103	Greater than 6”
Permeability (28 days) ASTM D5084	Less than 10^{-6} cm/sec

PART 3 -- EXECUTION

3.1 PRODUCTION

A. Foam generating equipment shall be used to produce a predetermined quantity of pre-formed foam which shall be mixed and blended with cementitious slurry. Equipment shall be calibrated to produce consistent foam that shall retain its stability until the cement sets to form a uniform cellular structure. The resulting cellular concrete shall have an essentially closed cell and low water absorptive characteristics.

B. Cellular Concrete shall be produced utilizing specialized automated proportioning, mixing, and foam producing equipment, which is capable of meeting the specified properties.

C. Avoid excessive handling of the material. After sufficient mixing of the foam with slurry, the material shall be conveyed promptly in its final location.

D. All equipment used must be approved by the foam manufacturer.

3.2 INSTALLATION

A. Place cellular concrete through various discharge ports inside the structures, injection points to the pipes, or other space in accordance with the contractor's submittal as approved by the ENGINEER.

B. Discharge ports and injection points should be a minimum of 3" pipe or 3" female threaded NPT.

C. Discharge or injection ports shall also be used to provide ventilation and to monitor the flow of grout.

D. All water and other residual materials must be removed prior to initiating filling procedure. If required, dewatering shall be continuous during installation of cellular concrete.

E. Backfilling shall be accomplished by placing backfill in a monolithic lift provided that placement methods will not induce movement of the pipes or other entities, overstressing or excessive deformation on pipe or structures, otherwise shall be performed and placed in lifts of 3-ft or as approved by the ENGINEER.

F. Take necessary precautions to protect and preserve the sheetpiles, structures and pipes from damage.

G. Volume of cellular concrete backfill shall be measured, recorded and compared with anticipated theoretical volume.

END OF SECTION

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SECTION 03 60 00 - GROUTING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide grout, complete and in place, in accordance with the Contract Documents. For concrete repair material and procedures, reference Section 03 01 30 – Concrete Repair and Rehabilitation.

B. Grout provided as a base support for mechanical and electrical equipment shall conform to manufacturer's requirements and the requirements of this section.

C. The following types of grout are covered in this Section:

1. Non-Shrink Grout

2. High Strength Non-Shrink Grout

3. Topping Grout and Concrete/Grout Fill

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. ASTM C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

B. ASTM C307 -- Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings

C. ASTM C531 – Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes

D. ASTM C579 – Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes

E. ASTM C580 – Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes

F. ASTM C827 – Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures

G. ASTM C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear

H. ASTM C1090 – Standard Test Method for Measuring Changes in Height of Cylindrical Specimens from Hydraulic-Cement Grout

I. ASTM C1107 – Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

J. ASTM C1116 – Standard Specification for Fiber-Reinforced Concrete

K. ASTM C1339 – Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

1. Certified testing lab reports for tests indicated herein.

2. Test results and service report from the field tests and the demonstration and training session verifying the requirements indicated herein.

3. Manufacturer’s literature containing instructions and recommendations on the mixing, handling, placement, curing, and appropriate uses for each type of grout used in the WORK, and location of use.

4. Documentation indicating that the grouts contain no chlorides or other chemicals that cause corrosion.

5. Manufacturer’s Safety Data Sheet documenting composition of grouts.

6. Submit manufacturer's written warranty as indicated herein.

7. Name and telephone number of grout manufacturer's representative who will give on-site service. The representative shall have at least one year of experience with the indicated grouts.

1.4 QUALITY ASSURANCE

A. Field Tests

1. Compression test specimens will be taken from the first placement of each type of grout, and at intervals thereafter selected by the ENGINEER. The specimens will be made by the ENGINEER or its representative.

2. Compression tests and fabrication of specimens for cement grout and cement based non-shrink grout will be performed in accordance with ASTM C1107 at intervals during construction selected by the ENGINEER.

3. Compression tests and fabrication of specimens for topping grout and concrete/grout fill will be performed in accordance with Section 03 31 00 - Cast-in-Place Concrete at intervals during construction selected by the ENGINEER.

4. Compression tests and fabrication of specimens for epoxy grouts will be performed in accordance with ASTM C579, Method B, at intervals during construction selected by the ENGINEER. A set of 3 specimens will be made for testing at 7 Days and each earlier time period as appropriate.

5. The cost of laboratory tests on grout will be paid by the OWNER except where test results show the grout to be defective. In such case, the CONTRACTOR shall pay for the tests, removal and replacement of Defective Work, and re-testing, all as part of the WORK.

6. The CONTRACTOR shall assist the ENGINEER in obtaining specimens for testing and shall furnish materials necessary for fabricating the test specimens.

B. Construction Tolerances: Construction tolerances shall be as indicated in Section 03 31 00 unless indicated otherwise.

C. Pre-Installation Demonstration and Training

1. Non-Shrink Grouts

a. The grout manufacturer shall give a demonstration and training session for the cement based and epoxy non-shrink grouts to be used on the project before any installation of grout is allowed.

b. The CONTRACTOR shall transport the test cubes to an independent test laboratory, obtain the test reports, and report these demonstration and training test cube strengths to the ENGINEER.

1.5 SPECIAL CORRECTION OF DEFECTS PROVISIONS

A. Manufacturer's Warranty

1. Furnish one year warranty for WORK provided under this section.

2. Manufacturer's warranty shall not contain a disclaimer limiting responsibility to the purchase price of products or materials.

PART 2 -- PRODUCTS

2.1 APPLICATION

A. Unless indicated otherwise, grouts shall be provided as listed below whether indicated on the Drawings or not.

Application	Type of Grout
Beam and column (1 or 2 story) base plates less than 16-inches in the least dimension.	Non-Shrink
Column base plates (greater than 2 story or larger than 16-inches in the least dimension)	High Strength Non-Shrink
Storage tanks and other non-motorized equipment or machinery under 30 horsepower	Non-Shrink
Filling blockout spaces for embedded items such as railing posts, gate guide frames, etc.	Non-Shrink
Toppings and concrete/grout fill less than 3-inches thick	Topping Grout
Toppings and concrete/grout fill greater than 3-inches thick	Structural Concrete per 03 31 00
Anchor bolts, anchor rods and reinforcing steel required to be set in epoxy or adhesive.	Post Installed Anchors in Concrete per Section 05 05 19
Repair of holes and defects in concrete members.	Concrete Repair and Rehabilitation per Section 03 01 30

2.2 NON-SHRINK GROUTS

A. General

1. All non-shrink grout shall be cement based unless otherwise noted.

2. Cement-based non-shrink grout shall be a prepackaged, inorganic, fluid, non-gas liberating, non-metallic, cement type grout requiring only the addition of water. Cement from kilns burning metal-rich hazardous waste fuel shall not be used.

3. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each non-shrink grout shall be as recommended by the manufacturer for the particular application.

4. The manufacturer’s product information shall state the acceptability of the non-shrink grout for the intended purpose and location.

5. Grout shall not contain chlorides or additives that may contribute to corrosion.

6. Grout placed in continuously wet environments or in exterior conditions shall not contain gypsum or calcium salt.

7. All cement-based non-shrink grout shall have the following general properties:

   a. Meet the requirements of ASTM C1107.

   b. Have a maximum early age height change of 4.0 percent expansion, and shall have no shrinkage (0.0 percent) in accordance with ASTM C827. The grout when tested shall not bleed or segregate at maximum allowed water.

   c. No shrinkage (0.0 percent) and a maximum of 0.3 percent expansion in the hardened state when tested in accordance with ASTM C1090.

   d. A minimum bond strength (concrete to grout) of 1900 psi per modified ASTM C882.

8. Environmental and ambient conditions shall be a factor in the selection of non-shrink grout. If a non-shrink grout is to be used in a high sulfate environment, marine environment, high temperature environment, or freeze/thaw environment, the manufacturer’s product information shall state the acceptability for each environmental condition.

9. Grout shall be suitable for use in freeze/thaw environments.

B. Non-Shrink Grout

1. Non-Shrink Grout shall have a minimum 28 Day compressive strength of 5000 psi when mixed at a fluid consistency and tested per ASTM C109.

2. Non-Shrink Grout shall be **Five Star Grout** by **Five Star Products, Five Star Fluid Grout 100** by **Five Star Products, Sikagrout 212** by **Sika Corporation,** or approved equal.

C. High Strength Non-Shrink Grout

1. High Strength Non-Shrink Grout shall have a minimum 28-Day compressive strength of 10,000 psi when mixed at a fluid consistency and tested per ASTM C109.

2. High Strength Non-Shrink Grout shall be **Five Star High Strength Grout** by **Five Star Products, Sikagrout 428 FS,** or approved equal.

2.3 TOPPING GROUT AND CONCRETE/GROUT FILL

A. Where fill thickness is 3-inches or greater, structural concrete as indicated in Section 03 31 00 - Cast-in-Place Concrete, may be used when accepted by the ENGINEER. Fiber reinforcing shall be as indicated below.

B. Grout for topping of slabs and concrete/grout fill for built-up surfaces of tanks, channels, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed as indicated. Materials and procedures indicated for structural concrete in Section 03 31 00 - Cast-in-Place Concrete, shall apply unless indicated otherwise.

C. Topping grout and concrete/grout fill shall contain a minimum of 564 pounds of cement per cubic yard with a maximum water/cement ratio of 0.45.

D. Coarse aggregate shall be graded as follows:

U.S. Standard Sieve Size	Percent By Weight Passing
1/2 in	100
3/8 in	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

E. Final mix design shall be as determined by trial mix design as indicated in Section 03 31 00, except that drying shrinkage tests are not required.

F. Topping grout and concrete grout/fill shall contain air-entraining agent per Section 03 31 00.

G. Strength: Minimum compressive strength of topping grout and concrete/grout fill at 28 days shall be 4500 psi.

H. Topping grout used where the fill thickness is 3 inches or greater shall contain fiber reinforcing, unless otherwise shown on the Contract Documents. Fiber reinforcing shall be 100 percent virgin polypropylene fibrillated fibers specifically manufactured in a blended gradation for use as concrete secondary reinforcement. Fibers shall be added at a rate of 1.5 pounds per cubic yard of concrete. Fibers shall conform to ASTM C1116.

2.4 CURING MATERIALS

A. Curing materials shall be in accordance with Section 03 31 00 and as recommended by the manufacturer of prepackaged grouts.

2.5 CONSISTENCY

A. The consistency of grout shall be as necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is defined such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as indicated herein for the particular application.

B. The slump for topping grout and concrete/grout fill shall be adjusted to match placement and finishing conditions but shall not exceed 4-inches.

2.6 MEASUREMENT OF INGREDIENTS

A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurements shall not be allowed.

B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Grout shall be stored in accordance with manufacturer's recommendations.

3.2 GENERAL

A. CONTRACTOR shall arrange for the manufacturer of prepackaged grouts to provide on-site technical assistance within 72 hours of request, as part of the WORK.

B. Grout shall not be placed until base concrete or masonry has attained its design strength, unless authorized otherwise by the ENGINEER.

C. When cementitious grouts are used on concrete surfaces, the concrete surface shall be saturated with water for 24 hours prior to placement. Upon completion of the saturation period, excess water shall be removed with clean, oil free compressed air prior to grouting. Concrete substrate shall not be wet prior to placement of epoxy grouts.

D. Surface preparation, curing, and protection of cement grout shall be in accordance with Section 03 31 00. The finish of the grout surface shall match that of the adjacent concrete unless otherwise indicated.

E. Surfaces that will be in contact with grout shall be free of dirt, loose rust, oil, wax, grease, curing compounds, laitance, loose concrete, and other deleterious materials.

F. Shade the WORK from sunlight for at least 24 hours before and 48 hours after grouting.

G. Contact the grout manufacturer's representative for assistance on hot and cold weather grouting techniques and precautions if applicable.

3.3 GROUTING PROCEDURES

A. General: Mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.

B. Structural, equipment, tank, and piping support bases shall be grouted, unless indicated otherwise.

1. The original concrete shall be blocked out or finished off a sufficient distance below the plate to provide for a minimum one-inch thickness of grout or other thickness if indicated.

2. After the base plate has been set in position at the proper elevation by steel wedges or double nuts on the anchor bolts, the space between the bottom of the plate and the original pour of concrete shall be filled with non-shrink-type grout through a headbox of appropriate size. The mixture shall be of a fluid consistency and poured continuously into the space between the plate and the base concrete. Forms for grout shall be tight against retaining surfaces, and joints shall be sealed as recommended by the grout manufacturer to be liquid-tight. Forms shall be coated as recommended by the grout manufacturer for easy form release. Where this method of placement is not practical or where required by the ENGINEER, alternate grouting methods shall be submitted by the CONTRACTOR for acceptance by the ENGINEER.

3. Concrete equipment pads for equipment bases that will be epoxy-grouted shall be sized so that, when the equipment base is fully grouted, the epoxy grout is stopped not less than 4-inches from the edge of the pad.

C. Topping Grout and Concrete/Grout Fill

1. Mechanical, electrical, and finish WORK shall be completed prior to placement of topping or concrete/grout fill. To ensure bonding to the base slab, the base slab shall be given an exposed aggregate finish. Alternatively, where accepted by the ENGINEER, the base slab shall be given a roughened textured surface by a close-spaced rake while the surface is green. After curing, high pressure washing shall expose the aggregates and produce not less than a 3/16-inch amplitude roughness. Jackhammers or chipping hammers shall not be used.

2. The minimum thickness of grout topping and concrete/grout fill shall be one-inch. Where the finished surface of concrete/grout fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 3-1/2 inches wide by 1-1/2 inches deep.

3. The base slab shall be thoroughly cleaned and wetted to saturated surface dry (SSD) condition per the International Concrete Repair Institute (ICRI) -- Technical Guide for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays, prior to placing topping grout and grout fill. No topping grout shall be placed until the slab is completely free from standing pools or ponds of water. A thin coat of neat cement grout shall be broomed into the surface of the slab just before topping or fill placement. The neat cement grout shall not be allowed to dry before topping placement. If it does dry, it must be immediately removed using wet stiff brooms and reapplied. The topping and fill shall be compacted by rolling or thorough tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to be installed shall be screeded by blades

attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment manufacturer after the grout is brought to the established grade. Coat surface with evaporation retardant as needed to prevent plastic shrinkage cracks.

4. Topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.

5. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping or fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement, or mixture of dry cement and sand shall be applied to the surface.

6. As soon as topping or fill finishing is completed, coat surface with curing compound.

3.4 CONSOLIDATION

A. Grout shall be placed in such a manner, for the consistency necessary for each application, to assure that the space to be grouted is completely filled.

END OF SECTION

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3.4 CONSOLIDATION

A. Grout shall be placed in such a manner, for the consistency necessary for each application, to assure that the space to be grouted is completely filled.

END OF SECTION

SECTION 05 05 19 – POST-INSTALLED ANCHORS IN CONCRETE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide post-installed anchors and appurtenances, complete and in place, as indicated in accordance with the Contract documents.

B. Unless otherwise indicated, drilled concrete anchors shall be adhesive anchors.

C. Section Includes:

1. Adhesive anchors

2. Expansion anchors

3. Screw anchors

4. Undercut anchors (dynamic loading)

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Definitions

1. Epoxy anchors are considered to be adhesive anchors.

2. Expansion anchors, screw anchors, and undercut anchors are considered to be mechanical anchors.

B. References

1. IBC 2012 – International Building Code

2. ACI 318 – Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary

3. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures and Commentary (ACI 350-06)

4. ACI 355.2 – Qualification of Post Installed Mechanical Anchors in Concrete and Commentary (ACI 355.2-07).

5. ASCE 7 – ASCE Standard ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures

6. ASCE 41-13 - ASCE Standard ASCE/SEI 41-13 Seismic Evaluation and Retrofit of Existing Buildings

7. ICC ES AC 193 – Mechanical Anchors in Concrete Elements

8. ICC ES AC 308 –Post Installed Adhesive Anchors in Concrete Elements

9. NSF 61 – NSF/ANSI 61-2016 Drinking Water System Components – Health Effects

1.3 SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Submit the following:

1. Product data and technical information

2. Safety Data Sheets (SDS) for adhesives

3. Manufacturer's literature containing installation instructions and appropriate uses for each type of post-installed anchor and location of use

4. Current ICC-ES or IAPMO-UES Evaluation Reports

5. Certification for each installer demonstrating that they have been qualified in accordance with the Quality Assurance requirements below

C. No substitution for the indicated anchors will be considered unless accompanied with an ICC-ES or IAPMO-UES report verifying strength and material equivalency.

D. Complete structural calculations and anchorage details shall be prepared and submitted by the Contractor for all anchors and anchor groups that are shown but not completely detailed (type, size, location, spacing and embedment) on the Contract Documents. Calculations and anchorage details shall be completed and submitted in accordance with Section 01 33 17 – Structural Design, Support and Anchorage.

1. Where adhesive anchors are used for structural applications (such as dowels between new and existing concrete) and an embedment depth is not shown on the contract documents, the anchor shall be installed in accordance with Method 1 or Method 2 below:

a. Method 1: The minimum depth of embedment shall be greater than or equal to the development length (l_d) determined in accordance with ACI 318 or 350, as applicable, for a cast in place reinforcing bar of the same diameter and grade, unless it can be shown by calculation that the anchor spacing and edge distance is sufficient to develop the tensile strength of the anchor in a lesser depth of embedment. Calculations shall be submitted in accordance with Section 01 33 00 – Contractor Submittals.

b. Method 2: Adhesive anchors in concrete that cannot develop the tensile capacity of the steel element may be used to transfer forces, provided that the loads on the anchor are amplified by the system overstrength factor (Ω_o) in Table 12.2-1 of ASCE 7-10, or where unreduced forces are used in accordance with ASCE 41-13 for existing structures. Calculations shall be submitted in accordance with Section 01 33 00 – Contractor Submittals.

1.4 QUALITY ASSURANCE

A. Special inspection for all post-installed anchor installations shall be provided:

1. As recommended or required by the ICC-ES or IAPMO-UES report.

2. As required by the enforceable building code.

3. As otherwise indicated in the Contract Documents.

B. The most stringent of the above requirements shall be used. The cost of Special Inspection of post-installed anchors shall be paid for by the OWNER.

C. Before installing adhesive anchors in the WORK, anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:

1. Hole drilling procedure, hole preparation and cleaning techniques, adhesive injection technique and dispenser training/maintenance, rebar dowel preparation and installation, and proof loading if required.

2. Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.

D. Before installing mechanical anchors in the WORK, anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:

1. Hole drilling procedure, hole preparation and cleaning techniques, and torqueing.

2. Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.

E. Defective anchors noted by the Special Inspector shall be replaced and re-installed by the CONTRACTOR without any additional compensation.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to job site in manufacturer’s or distributor’s packaging undamaged, complete with installation instructions.

B. Protect and handle materials in accordance with manufacturer’s recommendations to prevent damage or deterioration.

C. Anchoring adhesives shall be stored at temperatures prescribed by the manufacturer and must not be used beyond the expiration date.

1.6 SITE CONDITIONS

A. Post-installed anchors shall be installed in concrete having a minimum age of 21 days at time of anchor installation.

B. The anchor or fastener coating, plating, or steel type must provide suitable corrosion resistance for the environment in which the anchor or fastener is installed. Anchors, nuts, and washers in the locations listed below shall be fabricated from type 316 or 304 stainless steel:

1. buried locations

2. submerged locations

3. locations subject to seasonal or occasional flooding

4. inside hydraulic structures below the top of the structure

5. inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump

6. chemical handling areas

7. inside trenches, containment walls, and curbed areas

8. locations indicated or designated by the ENGINEER to be provided with stainless steel anchors.

PART 2 -- PRODUCTS

2.1 ADHESIVE ANCHORS

A. General

1. The adhesive anchor system shall consist of: 1) adhesive product; and 2) threaded rod or reinforcing bar insert. The complete system shall be compatible as required by the adhesive manufacturer.

2. Adhesives shall be injectable, two-component, cartridge-type systems dispensed and mixed through a static mixing nozzle supplied by the manufacturer.

3. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the adhesive anchor for the intended purpose and location.

4. Adhesive anchors shall be permitted when regular ambient temperatures are consistent with manufacturer's recommendation for long and short term temperatures.

5. Adhesive anchors shall not be used where anchors are subject to vibration or fire.

6. Adhesive anchors shall not be used in overhead applications.

7. Where required, adhesive shall be capable of being used in submerged applications once cured.

8. Adhesive shall meet the requirements of NSF/ANSI Standard 61, where applicable.

B. Adhesive Anchors in Concrete

1. Threaded rod inserts shall meet the requirements of Section 05 50 00- Miscellaneous Metalwork.

2. Reinforcing dowel inserts shall meet the material requirements of Section 03 21 00 – Reinforcement Steel and 03 31 00 – Cast-in-Place Concrete.

3. Adhesive for use in concrete adhesive anchors shall be certified for use in accordance with ICC-ES AC 308.

4. Where not detailed on the drawings, adhesive anchors shall be designed in accordance with ACI 318 as amended by the specific design provisions of ICC-ES AC 308.

5. Adhesive anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and shall have been tested and qualified for performance in cracked and uncracked

concrete in accordance ICC-ES AC308 to resist static, wind, and earthquake (Seismic Design Categories A through F).

6. Adhesive anchors for concrete shall be **Pure110+** by **Powers Fasteners, HIT-RE 500 V3** by **Hilti** or **SET-XP** by **Simpson Strong-Tie**, or equal.

2.2 EXPANSION ANCHORS

A. General

1. Expansion anchors are post-installed torque-controlled mechanical expansion anchors used to resist structural loads.

2. Expansion anchors shall be an imperial sized, threaded stud with an integral cone expander, expansion clip, nut and washer.

3. Lead caulking anchors will not be permitted.

4. Non-embedded buried or submerged anchors shall be fabricated from stainless steel.

5. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the expansion anchor for the intended purpose and location.

6. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

B. Expansion Anchors for Concrete

1. Anchors shall be designed in accordance with ACI 318, which requires post-installed mechanical anchors to be qualified according to ACI 355.2.

2. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ACI 355.2 and ICC-ES AC193.

3. Expansion anchors shall be **Strong-Bolt 2** by **Simpson Strong-Tie, Kwik-Bolt TZ** by **Hilti, Power-Stud+ SD1** by **Powers Fasteners**, or equal.

2.3 SCREW ANCHORS

A. General

1. Screw anchors used in exterior and corrosive environments shall be fabricated from stainless steel.

2. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the screw anchor for the intended purpose and location.

3. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

B. Screw Anchors for Concrete

1. Anchors shall be designed in accordance with ACI 318 as amended by the specific design provisions of ICC-ES AC193.

2. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ICC-ES AC193.

3. Screw anchors for concrete shall be **Titen HD** by **Simpson Strong-Tie, Kwik HUS-EZ (KH-EZ)** by **Hilti**, or equal.

2.4 UNDERCUT ANCHORS

A. General

1. Undercut anchors are post-installed mechanical anchors that require pre-drilling and a special undercut notch configuration cut into the concrete before installation.

2. Self-undercutting anchors are post-installed torque-controlled mechanical anchors that cut their own undercut notch by application of a setting torque that forces a sleeve over a cone.

3. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the undercut anchor for the intended purpose and location.

4. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

5. Undercut anchors used in exterior and corrosive environments shall be fabricated from stainless steel.

B. Undercut Anchors for Concrete

1. Anchors shall be designed in accordance with ACI 318 as amended by the specific design provisions of ICC-ES AC193.

2. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ACI 355.2 and ICC-ES AC193.

3. Undercut anchors for concrete shall be **HDA** by **Hilti, Atomic+** by **Powers Fasteners**, or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Post-installed anchors shall be installed in strict accordance with the manufacturer's instructions, the ICC-ES or IAPMO-UES report, and project specific design requirements indicated on the Contract Documents or in the design calculations provided by the CONTRACTOR per Section 1.3.D.

B. Where holes are drilled in concrete, holes shall be accurately and squarely drilled, and the holes shall be cleaned in accordance with the manufacturer's recommendations.

C. Post-installed anchors shall not be installed until the concrete has reached the required 21 days or per manufacturer's requirements, whichever is longer.

D. Acceptable installation and performance temperature ranges shall be verified with manufacturer's literature prior to installation. Minimum substrate temperatures shall be maintained during the full curing period as required by the manufacturer.

E. Adhesive anchors shall not be loaded until the adhesive has reached its indicated strength in accordance with the manufacturer's instructions.

F. The CONTRACTOR shall identify the position of reinforcing steel and other embedded items prior to drilling holes. Care shall be exercised in drilling to avoid damaging existing reinforcing or embedded items. The location of drilled holes shall be adjusted to avoid drilling through or cutting any existing reinforcing bars or embedded items. Notify the ENGINEER if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and communications conduit, and piping.

G. Core drilling of holes is not allowed.

H. Identification of reinforcing steel and/or embedded items, relocation of drilled holes and adjustments or modifications to anchored or fastened items shall be considered part of the WORK and shall be provided at no additional cost to the OWNER.

I. All abandoned drilled holes shall be repaired in accordance with Section 03 01 30 Concrete Repair and Rehabilitation at no additional cost to the OWNER.

END OF SECTION

SECTION 05 50 00 – MISCELLANEOUS METALWORK

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide miscellaneous metalwork and appurtenances, complete and in place, as indicated in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Federal Specifications

MIL-G-18015 A (3)	(Ships) Aluminum Planks (6063-T6)
MIL-PRF-907F	Antiseize Thread Compound, High Temperature

B. Codes

OSHA 1910.23	Fixed Ladders

C. Commercial Standards

AA-M32C22A41	Aluminum Association
AASHTO HS-20	Truck Loading
AISC	Manual of Steel Construction
AISI	Design of Light Gauge, Cold-Formed Steel Structural Members
ASTM A 36	Carbon Structural Steel
ASTM A 48	Gray Iron Castings
ASTM A 53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 193	Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service
ASTM A 194	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
ASTM A 307	Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A 500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 992	Steel for Structural Shapes for Use in Building Framing
ASTM F 1554	Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength
ANSI/AWS D1.1	Structural Welding Code - Steel
ANSI/AWS D1.2	Structural Welding Code - Aluminum
ANSI/AWS QC1	Qualification and Certification of Welding Inspectors

1.3 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Shop Drawings shall conform to AISC recommendations and specifications, and shall show holes, and the like, as may be required for other parts of the WORK.

2. Shop Drawings shall include complete details of members and connections, anchor bolt layouts, schedules for fabrication procedures, and diagrams for the sequence of erection.

C. Grating

1. Submit layout drawings for grating, showing the direction of span, type and depth of grating, size and shape of grating panels, seat angle details, and details of grating hold down fasteners.

2. Submit load and deflection tables for each style and depth of grating used.

D. Anchor Submittals

1. For post installed anchors in concrete other than powder-drive pins or impact anchors, refer to Section 05 05 19 – Post Installed Anchors in Concrete.

2. For cast in place anchors, powder-drive pins or impact anchors, complete structural calculations and anchorage details shall be prepared and submitted by the Contractor for all anchors and anchor groups that are shown but not completely detailed (type, size, location, spacing and embedment) on the Contract Documents. Calculations and anchorage details shall be signed and stamped by a Professional Engineer registered in the State of Illinois.

E. Aluminum Railing Submittals

1. Shop Drawings: Include railing layouts, post locations, and spacings, gate locations, removable railing sections, connectors, construction details, manufacturer's engineering data, installation instructions, product data, and any deviation requests.

2. Calculations: Engineering structural calculations for railings, handrail brackets, brackets, support flanges, fasteners and anchors. Calculations and anchorage details shall be signed and stamped by a Professional Engineer registered in the State of Illinois.

1.4 QUALITY ASSURANCE

A. Weld procedures and welder qualifications shall be available in the CONTRACTOR's field office for review.

B. Welding Special Inspection shall be performed by the OWNER in accordance with the enforceable Building Code.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Steel

Wide Flange Shapes	ASTM A 992
Shapes, Plates, Bars	ASTM A 36
Pipe, Pipe Columns, Bollards	ASTM A 53, Type E or S, Grade B standard weight unless indicated otherwise
HSS	ASTM A 500 Grade B

B. Corrosion Protection

1. Unless otherwise indicated, fabricated steel metalwork which will be used in a corrosive environment and/or will be submerged in water or wastewater shall be coated in accordance with the requirements of Section 09 96 00 - Protective Coating, and shall not be galvanized prior to coating.

2. Other miscellaneous steel metalwork shall be hot-dip galvanized after fabrication.

C. Stainless Steel

1. Unless otherwise indicated, stainless steel metalwork and bolts shall be fabricated from Type 316 stainless steel.

D. Aluminum

1. Unless otherwise indicated, aluminum metalwork shall be fabricated from Alloy 6061-T6.

2. Aluminum in contact with concrete, masonry, wood, porous materials, or dissimilar metals shall have contact surfaces coated in accordance with the requirements of Section 09 96 00 - Protective Coating.

E. Cast Iron

1. Unless otherwise indicated, iron castings shall conform to the requirements of ASTM A 48, Class 50B, or better.

2.2 ALUMINUM RAILINGS

A. General

1. Aluminum handrails and railings shall be component systems, complete with anchors, attachments, balusters, brackets, caps, fasteners, gates (swing with self-latching hardware or be removable), posts, sleeves, trim, and any other related items as required or necessary for a complete installation.

2. Gates and removable rail sections shall be complete with hardware such as self-closing hinges, self-latching latches, hasps, and the like.

3. Railings shall conform to Building Code and OSHA requirements, General Industry Occupational Safety and Health Standards (29CFR1910).

B. Materials shall conform to the following requirements:

1. Aluminum

a. Aluminum shall be U.S. Alloy 6063 T-5 or T-6.

b. Aluminum pipe rail shall not be less than 1-1/2-inch diameter Schedule 40 pipe.

2. Electrolysis protective material shall be in accordance with the requirements of Section 09 96 00 - Protective Coating.

3. Sleeves shall be of galvanized steel or PVC.

4. Grout for handrail posts shall consist of an inorganic, non-shrink, non-metallic premixed grout in accordance with the requirements of Section 03 60 00 - Grouting, with a minimum 28-Day compressive strength of 4,000 psi.

5. Fasteners, screws, and bolts shall be concealed and shall be fabricated from stainless steel or aluminum.

6. Aluminum welding rods shall be of a type recommended by the aluminum manufacturer for anodized finished products.

7. Kickplates shall be provided on railings and not set in curbs.

C. Pipe railing systems, including handrails, railings, tube caps, and other miscellaneous parts of the rails, shall be provided with a clear anodized finish, AA-M32C22A41.

D. Manufacturers or Equal

1. **C-V Pipe Rail** by **Crane Veyor Corp.**

2. **Connectorail** by **Julius Blum and Co.**

2.3 LADDERS

A. Materials

1. Ladders which may be partially or wholly submerged or which are located inside a hydraulic structure shall be fabricated entirely of Type 316 stainless steel.

2. Other ladders shall be fabricated from aluminum.

B. Ladder rungs shall be **Anti-Slip Metal Ladder Rungs** by **SlipNOT**, or approved equal. Material shall be compatible with ladder system based on location, as indicated above.

1. Ladder rungs shall be round, knurled, and provided will mill finish.

C. Pop-Up Extension

1. Every ladder that does not extend above the access level shall be equipped with a pop-up ladder extension.

2. The pop-up ladder extension device shall be manufactured of the same material and finish as the ladder, and shall be provided with a telescoping tubular section that locks automatically when fully extended.

3. Upward and downward movement shall be controlled by stainless steel spring balancing mechanisms.

4. The units shall be completely assembled with fasteners for securing to the ladder rungs in accordance with the manufacturer's instructions.

5. Pop-up Extension shall be **LadderUP Safety Post, LU-4** by **Bilco**, or Owner approved equal.

2.4 METAL GRATING

A. General

1. Metal grating shall be of the indicated design, size, and type.

2. Grating shall be supported around an opening by support members.

3. Where grating is supported on concrete, unless otherwise indicated provide embedded support angles that match the grating material and are mitered and welded at their corners.

4. Banding

a. The grating shall be completely banded at edges and cutouts.

b. The banding material and cross-section shall be equivalent to the bearing bars.

c. The banding shall be welded to each cut bearing bar.

5. The grating pieces shall be fastened to each support in 2 locations.

6. Where grating forms the landing at the top of a stairway, the edge of the grating that forms the top riser shall have an integral non-slip nosing with a width equal to that of the stairway.

7. Where the grating depth is not indicated, provide grating within allowable stress levels and which shall not exceed a deflection of 1/4 inch or the span divided by 180, whichever is less.

8. Design Loading

a. For standard duty plank and safety grating, the loading to be used for determining stresses and deflections shall be the uniform live load of the adjacent floor or 100 psf, whichever is greater, or a concentrated load of 1000 pounds.

b. For heavy duty grating, the loading used for determining stresses and deflections shall be in accordance with AASHTO HS-20.

B. Material

1. Except where indicated otherwise, bar grating shall be fabricated entirely of fiberglass reinforced plastic (FRP).

2. Grating that may be partially or wholly submerged shall be fabricated entirely of Type 316 stainless steel

C. Standard-Duty Grating

1. No single piece of grating shall weigh more than 80 pounds, unless indicated otherwise.

2. Standard duty grating shall be composed of serrated bar grating.

3. Cross bars shall be welded or mechanically locked tightly into position such that there is no movement between the bearing and cross bars.

2.5 CHECKERED PLATE

A. Checkered plate shall be provided with a pattern of raised lugs on one face, and shall be smooth on the opposite face.

B. Lugs

1. Lugs shall be a minimum of one inch in length and raised a maximum of 1/2 inch above the surface.

2. The lugs shall be located in a pattern in which the lugs are oriented at 90 degrees from the adjacent lugs in 2 orthogonal directions.

3. The rows of lugs shall be oriented at 45 degrees from the edges of the plates.

C. Where no material is indicated, the plates shall be fabricated from aluminum.

D. Unless indicated otherwise, the minimum plate thickness shall be as required to limit deflection resulting from a live load of 100 psf to 1/4 inch, or the span divided by 240, whichever is less.

2.6 HATCHES

A. Where access hatches are mounted on a floor slab (including top slabs that are not covered with a roofing membrane) or on a concrete curb, the hatch shall be flush-type as indicated.

B. Hatches shall be fabricated from aluminum 5086 H34, 6063-T5 or 6061-T6, unless otherwise indicated.

C. Hatch hardware shall be fabricated from Type 316 stainless steel, and shall be of the gutter-type.

D. The design live load shall be 300 psf, unless indicated otherwise.

E. Configuration

1. Hatch opening sizes, number and swing direction of door leaves, and locations shall be as indicated.

2. Indicated sizes are for the clear opening.

3. Where the number of leaves is not indicated, openings larger than 42 inches in either direction shall be provided with double-leaf doors.

4. Unless indicated otherwise, hinges shall be located on the longer dimension side.

5. Unless indicated otherwise, ladder hatches shall be a minimum of 30 inches wide by 36 inches long, with the ladder centered on the shorter dimension and the door hinge opposite the ladder.

F. Door leaves shall be fabricated from a minimum of 1/4-inch thick checkered-pattern plate.

G. Channel frames shall be fabricated from a minimum 1/4-inch material with an anchor flange around the perimeter.

H. Hatches shall be provided with an automatic hold-open arm with release handle.

I. Hatches shall be designed for easy opening from both inside and outside.

J. Hatches shall be designed to be water-tight and shall be equipped with a joint gutter, a moat-type edge drain, and drain piping of the length and size necessary to remove the drain water from all dry spaces accessed by the hatch.

K. A minimum 1-1/2 inch diameter drain connection shall be provided, located by the manufacturer.

L. Hatches shall be provided with a recessed hasp for a padlock covered by a hinged lid that is flush with the surface.

M. Hatches shall be **Bilco Type J** or **JD, Babcock-Davis Type B-FGA**, or equal.

N. Nets

1. Unless indicated otherwise, hatch nets shall be provided on floor hatches.

2. Hatch nets shall conform to OSHA requirements.

3. Hatch nets shall be **Hatch Net 121**, as manufactured by **Safe Approach, Inc,** Auburn, ME, or equal.

2.7 IRON CASTINGS

A. General

1. Iron castings shall be of uniform quality, free from blowholes, porosity, hard spots, shrinkage, distortion, or other defects.

2. The castings shall be smooth and well cleaned by shotblasting.

3. Covers and grates shall fit together evenly, such that the cover fits flush with the surrounding finished surface and such that the cover does not rock or rattle when a loading is applied.

4. Round covers and frames shall be provided with machined bearing surfaces.

B. Covers and grates with matching frames shall be designed to support the following loadings:

1. Where located within a structure, the design loading shall match that required for the adjacent floor area, or, if no floor loading is indicated, a minimum of 300 pounds per square foot.

2. Exterior covers and grates shall be designed for AASHTO HS-20 loading unless indicated otherwise.

2.8 MANHOLE RUNGS

A. Rungs shall meet ASTM C 478 - Precast Reinforced Concrete Manhole Sections and the following requirements:

1. Rungs shall be spaced not less than 10 inches apart nor more than 14 inches apart, as measured between centerlines of the rungs.

2. Rungs shall be parallel, level, and uniformly spaced.

3. The rungs shall be shaped such that a person's foot cannot slide off the end of the rung.

4. Rungs shall be surfaced to prevent injury from punctures or lacerations, and to prevent snagging of clothing.

5. The minimum perpendicular clearance between rungs and any obstruction behind the ladder shall be 6 inches.

6. The minimum width of rungs shall be 14 inches.

B. Submit certified test results in accordance with ASTM C 497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile, Section 10, for the following loads:

1. The horizontal pull-out load shall be 400 pounds.

2. The vertical load shall be 800 pounds.

C. Material

1. Rungs shall be fabricated from co-polymer polypropylene that encapsulates a minimum 1/2-inch grade 60 steel reinforcing rod.

2. The co-polymer polypropylene shall meet ASTM D 4101, Type PP200B33430.

2.9 BOLTS AND ANCHORS

A. Standard Service (Non-Corrosive Application)

1. Bolts, anchor rods, anchor bolts, washers, and nuts shall be fabricated from steel as indicated.

2. Threads on galvanized bolts, rods and nuts shall be formed with suitable taps and dies such that they retain their normal clearance after hot-dip galvanizing.

3. Except as otherwise indicated, steel for bolt material, anchor rods, anchor bolts, and cap screws shall be in accordance with the following requirements:

a. Structural Connections: ASTM A 307, Grade A or B, hot-dip galvanized

b. Headed Anchor Rods and Anchor Bolts: ASTM F1554, Grade 36, hot-dip or mechanically galvanized with Grade A matching nuts

c. High-Strength Bolts, where indicated: ASTM A 325

d. Pipe and Equipment Flange Bolts: ASTM A 193, Grade B-7

B. Corrosive Service

1. Bolts, anchor rods, anchor bolts, nuts, and washers in the locations listed below shall be fabricated from stainless steel as indicated.

a. buried locations

b. submerged locations

c. locations subject to seasonal or occasional flooding

d. inside hydraulic structures below the top of the structure

e. inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump

f. chemical handling areas

g. inside trenches, containment walls, and curbed areas

h. locations indicated or designated by the ENGINEER to be provided with stainless steel bolts

C. Unless otherwise indicated, stainless steel bolts, nuts, anchor rods, and washers shall be fabricated from Type 316 stainless steel, Class 2, conforming to ASTM A 193 for bolts and to ASTM A 194 for nuts.

D. Coating

1. Threads on stainless steel bolts and rods shall be protected with an antiseize lubricant suitable for submerged stainless steel bolts, meeting government specification MIL-A-907E.

2. Buried bolts in poorly drained soil shall be coated the same as the buried pipe.

3. Antiseize lubricant shall be classified as acceptable for potable water use by the NSF.

4. Antiseize lubricant shall be "PURE WHITE" by **Anti-Seize Technology,** Franklin Park, IL, 60131, **AS-470** by **Dixon Ticonderoga Company,** Lakehurst, NJ, 08733, or equal.

E. Bolt Requirements

1. The bolt and nut material shall be free-cutting steel.

2. The nuts shall be capable of developing the full strength of the bolts.

3. Threads shall be Coarse Thread Series conforming to the requirements of the American Standard for Screw Threads.

4. Bolts and cap screws shall have hexagon heads and nuts shall be Heavy Hexagon Series.

5. Bolts and nuts shall be installed with washers fabricated from material matching the base material of bolts, except that hardened washers for high-strength bolts shall conform to the requirements of the AISC Specification.

6. Lock washers fabricated from material matching the bolts shall be installed where indicated.

7. The length of each bolt shall be such that the bolt extends at least 1/8 inch beyond the outside face of the nut before tightening, except for anchor bolts which shall be flush with the face of the nut before tightening.

2.10 POWDER-DRIVEN PINS

A. Powder-driven pins for installation in concrete or steel shall be fabricated from heat-treated steel alloy.

B. If the pins are not inherently sufficiently corrosion-resistant for the conditions to which they will be exposed, they shall be protected in an acceptable manner.

C. Pins shall have capped or threaded heads capable of transmitting the loads the shanks are required to support.

D. Pins that are connected to steel shall be provided with longitudinal serrations around the circumference of the shank.

2.11 IMPACT ANCHOR

A. Impact anchors shall be an expansion-type anchor in which a nail-type pin is driven to produce the expansive force.

B. The pin shall be provided with a zinc sleeve with a mushroom-style head and stainless steel nail pin.

C. Anchors shall be **Zinc Nailon Anchors**, manufactured by **Simpson Strong-Tie, Inc.**, **Metal Hit Anchors,** manufactured by **Hilti, Inc., Rawl Zamac Nailin,** manufactured by the **Rawlplug Company,** or equal.

PART 3 -- EXECUTION

3.1 FABRICATION AND INSTALLATION REQUIREMENTS

A. **Fabrication and Erection:** Except as otherwise indicated, the fabrication and erection of structural steel shall conform to the requirements of the American Institute of Steel Construction "Manual of Steel Construction."

B. Aluminum Railings

1. Aluminum railing fabrication and installation shall be performed by craftsmen experienced in the fabrication of architectural metalwork.

2. Exposed surfaces shall be free from defects or other surface blemishes.

3. Dimensions and conditions shall be verified in the field.

4. Joints, junctions, miters, and butting sections shall be precision fitted with no gaps occurring between sections, and with surfaces flush and aligned.

5. Electrolysis protection of materials shall be provided.

C. Unless otherwise indicated, provide a 1/2-inch drain line to the nearest floor drain for floor hatches.

D. Powder-Driven Pins

1. Powder-driven pins shall be installed by a craftsperson certified by the manufacturer as being qualified to install the manufacturer's pins.

2. Pins shall be driven in one initial movement by an instantaneous force that has been carefully selected to attain the required penetration.

3. Driven pins shall conform to the following requirements where "D" is equal to the pin shank diameter:

Material Penetrated by Pin	Material Minimum Thickness	Pin Shank Penetration in Supporting Material	Minimum Space From Pin's CL to Edge of Penetrated Material	Minimum Pin Spacing
Concrete	16D	6D minimum	14D	20D
Steel	1/4-inch	Steel thickness	4D	7D

3.2 WELDING

A. Method

1. Welding shall be performed by the metal-arc method or gas-shielded arc method as described in the American Welding Society "Welding Handbook" as supplemented by other pertinent standards of the AWS.

2. The qualification of the welders shall be in accordance with the AWS Standards.

B. Quality

1. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained in order to minimize distortion and for control of dimensions.

2. Weld reinforcement shall be as indicated by the AWS Code.

3. Upon completion of welding, remove weld splatter, flux, slag, and burrs left by attachments.

4. Welds shall be repaired in order to produce a workmanlike appearance, with uniform weld contours and dimensions.

5. Sharp corners of material that is to be painted or coated shall be ground to a minimum of 1/32 inch on the flat.

3.3 GALVANIZING

A. Structural steel plates shapes, bars, and fabricated assemblies required to be galvanized shall, after the steel has been thoroughly cleaned of rust and scale, be galvanized in accordance with the requirements of ASTM A 123.

B. Any galvanized part that becomes warped during the galvanizing operation shall be straightened.

C. Bolts, anchor rods, anchor bolts, nuts, and similar threaded fasteners, after being properly cleaned, shall be galvanized in accordance with the requirements of ASTM A 153.

D. Field Repairs

1. Field repairs to damaged galvanizing shall be performed by preparing the surface and applying a coating.

2. Surface preparation shall consist of removing oil, grease, soil, and soluble material by cleaning with water and detergent (SSPC SP1) followed by brush-off blast cleaning (SSPC SP7) over an area extending at least 4 inches into the undamaged area.

3. The coating shall be applied to at least 3 mils dry film thickness, and shall be **Zinc-Clad XI** by **Sherwin-Williams**, **Galvax** by **Alvin Products**, **Galvite** by **ZRC Worldwide**, or equal.

END OF SECTION

SECTION 06 80 00 - FIBER GLASS REINFORCED PLASTIC FABRICATIONS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide fabricated fiberglass reinforced plastic (FRP) items, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings: Shop Drawings for every FRP item. Include plans, elevations, and profiles that clearly show material sizes, types, styles, part or catalog numbers. Drawings shall include complete details for the fabrication and erection of components, including location, dimensions, lengths, joining method, type and size of fasteners, clip angles, member sizes, and connection details.

C. Layout drawings for grating shall show the direction of span, type and depth of grating, size and shape of grating panels, seat angle details, and details of grating hold down fasteners.

D. Product Literature: Manufacturer's published literature including structural design data, structural properties, and load and deflection tables for each style and depth of grating, corrosion resistance tables, certificates of compliance, test reports (as applicable), anchoring system allowable load tables and ICBO reports.

E. Calculations and Design Details: Structural calculations and complete design details shall be submitted for structural shapes, brackets, support flanges, fasteners and anchors. Calculations and design details shall be signed and sealed by a professional engineer registered in the State of Illinois.

F. Samples: Samples of each type of product shall be submitted if requested by the ENGINEER.

G. Certification: The CONTRACTOR shall certify on the Shop Drawings that items and fabrications have been manufactured of materials suitable for potable water usage per NSF 61, and that fabricated items are of sufficient strength to serve their intended function without undue distortion or deflection.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Items provided under this Section shall be furnished only by manufacturers having experience in the manufacture of similar products, with a record of 5 similar successful installations in the last 5 years.

B. Quality: Fiberglass items shall be constructed of new, first-class, commercial-quality, fiberglass fabric-reinforced polyester or vinyl ester resin laminate material of the strength, thickness, and dimensions indicated, using the matched die-molded method.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. FRP items shall be composed of fiberglass reinforcement and resin in quantities, qualities, properties, arrangements, and dimensions as necessary to meet the design requirements and dimensions indicated.

B. Fiberglass reinforcement shall be continuous roving, continuous strand mat, and surfacing veil or a combination thereof in sufficient quantities for the application and physical properties required.

C. Unless indicated otherwise, resin shall be fire retardant isophthalic polyester or vinyl ester with chemical formulation as necessary to provide the corrosion resistance, strength, and other physical properties as required. FRP items used in chemical storage or containment areas shall be vinyl ester resin, with chemical formulations as necessary to provide the corrosion resistance, strength, and other physical properties required in those areas.

D. Finished surfaces of FRP items and fabrications shall be smooth, resin-rich, free of voids, and without dry spots, cracks, crazes, or unreinforced areas. Glass fibers shall be well covered with resin to protect against exposure from wear or weathering.

E. Resin shall include an ultraviolet (UV) inhibitor additive. FRP products located in exterior locations exposed to the weather or in UV facilities shall also have an additional 1-mil UV-resistant coating applied.

F. FRP products shall have a tested flame spread rating of 25 or less per ASTM E 84 - Surface Burning Characteristics of Building Materials. Gratings and stair treads shall also meet the self-extinguishing requirements of ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.

G. Supports and Fasteners: The CONTRACTOR shall provide bolts, anchor bolts, nuts, washers, and supports as required for the WORK of this Section in accordance with the requirements of the manufacturers of the items. Bolts, anchor bolts, washers, and supports shall be Type 316 stainless steel. Concrete anchor systems shall be in accordance with Section 05 50 00 – Miscellaneous Metalwork.

H. Cut or machined edges, holes, scratches, gouges, and abrasions shall be sealed with a resin compatible with the resin matrix used in the original item.

2.2 FIBERGLASS GRATING

A. General

1. Seat Angles: Where grating is supported on concrete members, continuous embedded seat angles shall be provided on all sides. Grating seat angles shall be made of FRP and be as detailed on the Drawings; except that specially manufactured pultruded FRP seat angles intended to be cast in concrete may be submitted for acceptance by the ENGINEER.

2. Load/Deflection Requirements: Grating shall be capable of spanning the distances indicated with a minimum safety factor of 3 for stresses and without exceeding a deflection equal to the lesser of 1/4-inch or the span divided by 180. The loading used for determining stresses and deflections shall be the uniform live load of the

adjacent floor area or 3300 pounds per square foot, whichever is greater, or a concentrated load of 1000 pounds at the center of the span, unless otherwise indicated.

3. Color: The color of the grating and seat angles shall match. The color shall be high visibility safety yellow. The color selected shall result in no additional cost to the OWNER.

4. The top surface of grating shall be provided with a non-slip surface by embedding or bonding grit to the FRP.

5. Penetrations: Cutouts shall be provided were needed for penetrations through the grating. The grating shall be reinforced where necessary to meet the load/deflection requirements despite the cutouts.

6. Dimensional Requirements: When grating is designed to span primarily in one direction, the grating shall be fabricated to span in the shorter span direction, unless indicated otherwise. Individual pieces of grating shall not exceed 80 pounds in weight, unless indicated otherwise.

7. Mechanical grating clips shall be manufactured of Type 316 stainless steel. Grating hold-down clips shall be provided, spaced at a maximum of 4-feet apart or as recommended by the manufacturer, whichever is less. A minimum of 4 clips per piece of grating is required.

2.3 MOLDED FRP GRATING

A. Molded FRP grating shall be of a one piece molded construction with tops and bottoms of bearing bars and cross bars in the same plane. Grating shall have a square mesh pattern.

B. Gratings shall be reinforced with continuous rovings of equal number of layers in each direction to provide bidirectional load bearing.

C. Non-slip surfacing: Grating shall have grit on the top of each bar for maximum slip resistance.

D. Molded FRP grating shall be **Fibergrate** by **Fibergrate Composite Structures, Inc., Corgrate Molded Fiberglass Grating** by **IKG Industries, Duragrate** by **Strongwell**; or equal.

2.4 STRUCTURAL SHAPES

A. Structural shapes shall be manufactured by the pultrusion process and have a maximum of 55 percent and a minimum of 45 percent glass content (by weight).

B. Pultruded structural shapes are to have the minimum longitudinal mechanical properties listed below:

Property	ASTM Method	Minimum Value	Units
Tensile Stress (Lengthwise)	D 638	30,000	psi
Tensile Modulus (Lengthwise)	D 638	2.5×10^6	psi
Flexural Stress (Lengthwise)	D 790	30,000	psi
Flexural Modulus (Lengthwise)	D 790	1.6×10^6	psi
Short Beam Shear (Lengthwise)	D 2344	4,500	psi
Shear Modulus (Lengthwise)	N/A	4.2×10^5	psi
Coefficient of Thermal Expansion (Lengthwise)	D 696	4.4×10^{-6}	in/in/°F

C. FRP structural shapes shall be **Dynaform Fiberglass Structural Shapes** by **Fibergrate Composite Structures, Inc, Extren** by **Strongwell, CorLight by IKG Fiberglass Systems**, or equal.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY AND STORAGE

A. Delivery of Materials: Manufactured materials shall be delivered in original, unbroken pallets, packages, containers, or bundles bearing the label of the manufacturer. Adhesives, resins, catalysts, and hardeners shall be crated or boxed separately.

B. Storage of Products: Materials shall be carefully handled to protect them from abrasion, cracking, chipping, twisting, deformations, and other types of damage. Store items in an enclosed area and free from contact with soil and water. Store adhesives, resins, catalysts, and hardeners in dry indoor storage facilities between 70 and 85 degrees F (21 to 29 degrees C). There shall be labels on the outside of the boxes indicating that the products shall be stored as described above.

3.2 GENERAL

A. FRP products shall meet the dimensional requirements and tolerances indicated. The CONTRACTOR shall verify measurements and determine correct size and locations of required holes or cutouts from field dimensions before fabrication.

B. FRP products shall be fabricated free from warps, twists, or other defects that affect appearance and serviceability.

C. The CONTRACTOR shall give ample notice prior to the beginning of any fabrication work so that the ENGINEER can perform shop inspections.

D. The CONTRACTOR shall install FRP structures in accordance with the manufacturer's assembly drawings. Field cut and drill FRP products with carbide or diamond tipped bits and blades. Seal cut or drilled surfaces in accordance with manufacturer's instructions.

Follow manufacturer’s instructions when cutting or drilling fiberglass products or using resin products.

E. Bonding of FRP items shall be through the use of an epoxy adhesive recommended by the manufacturer of the particular item. The surfaces to be bonded shall be solvent cleaned and abraded sufficiently to remove the surface gloss and to remove any mold release agent or other contaminants which may interfere with proper bonding. The adhesive manufacturer's instructions and recommendations shall be followed. The items bonded shall not be stressed until at least 48 hours have passed.

3.3 GRATING

A. Layout: Each grating section shall be readily removable except where indicated. As much as possible, manufacturer shall provide openings and holes where indicated on the Contract Drawings. Grating openings which fit around protrusions (pipes, cables, machinery, etc.) shall be discontinuous at approximately the centerline of opening so each section of grating is readily removable.

1. Install the grating with a minimum 1.5-inch bearing surface at the support ends.

2. Tolerances between sections shall provide for not more than 1/4-inch clearance between adjacent sections or between grating and frames. Adjacent sections shall line up to form an uninterrupted straight line where possible.

3. The grating shall be as free, as commercially possible from visual defects such as foreign inclusions, delamination, blisters, resin burns, air bubbles, and pits. The surface shall have a smooth finish (except for non-slip surfaces).

4. Seat angles shall be mitered and bonded at corners to produce smooth, even, level seating surface.

5. Grating shall be installed so that the top surface is level and even with adjacent walking surfaces. There shall be no protrusions above the top surface.

6. Grating shall be fastened to supports.

3.4 STRUCTURAL SHAPES

A. Measurement: The CONTRACTOR shall verify dimensions, making any field measurements necessary, and shall be fully responsible for accuracy and layout of WORK. The CONTRACTOR shall review the Drawings, and any discrepancies shall be reported to the ENGINEER for clarification prior to starting fabrication.

B. Fabrication

1. Structural FRP shall be fabricated in accordance with the Contract Drawings and as indicated on the Shop Drawings.

2. Materials shall be properly marked and match-marked for field assembly.

3. Where finishing is required, assembly shall be completed including bolting before starting of finishing operations.

C. Connections: Shop and field connections shall be bonded and bolted as indicated. Unless indicated otherwise, connections shall develop full strength of members joined.

D. Holes for other WORK: Holes shall be provided as necessary or as indicated for securing other WORK to FRP framing, and for the passage of other WORK through FRP members. Threaded nuts shall be epoxied to framing, and other specialty items as indicated to receive other WORK. Field cuts and drilled edges shall be sealed with a resin compatible with the original resin and recommended by the manufacturer. The sealing of the edges shall prevent premature fraying at the field cut edges.

E. Erection

1. Anchor bolts and other connectors required for securing structural FRP to in-place WORK and templates and other devices for presetting bolts and other anchors to accurate locations shall be furnished by the CONTRACTOR.

2. The CONTRACTOR shall be responsible for designing and installing any temporary bracing required for the safe erection of all structural FRP members.

F. Setting bases and bearing plates

1. Prior to the placement of non-shrink grout beneath base and bearing plates, the bottom surface of the plates shall be cleaned of bond-reducing materials. Concrete and masonry bearing surface shall also be cleaned of bond-reducing materials and be roughened to improve bonding.

2. Loose and attached base plates and bearing plates for structural members shall be set on wedges, leveling nuts, or other adjustable devices.

3. Anchor bolts shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its required strength.

4. Base plates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure.

G. Field Assembly

1. Structural frames shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before permanent fastening. Bearing surfaces and other surfaces that will be in permanent contact shall be cleaned before assembly. Necessary adjustments to compensate for discrepancies in elevations and alignments shall be performed.

2. Individual members of the structure shall be leveled and plumbed within required tolerances. The CONTRACTOR shall provide and install all temporary bracing required until structure is complete.

H. Misfits at Bolted Connections

1. Where misfits in bolting are encountered, the ENGINEER shall be immediately notified. The CONTRACTOR shall submit a method to remedy the misfit for review by the ENGINEER. The ENGINEER will determine whether the remedy is acceptable or if the member must be refabricated. Methods of remedy may include, but are not limited to the following:

a. Reaming holes that must be enlarged to admit oversized bolts.

b. Drilling additional holes in the connection, to conform to manufacturer's standards for bolt spacing, end, and edge distances, and adding additional bolts.

c. Rejecting the improperly fabricated member and fabricating a new member to ensure proper fit.

2. Mis-sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins.

3. The CONTRACTOR shall pay costs associated with the repair of misfits.

END OF SECTION

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SECTION 09 96 00 - PROTECTIVE COATING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide protective coatings, complete and in place, in accordance with the Contract Documents.

B. Definitions

1. The term "paint," "coatings," or "finishes" as used herein, shall include surface treatments, emulsions, enamels, paints, epoxy resins, and other protective coatings, excepting galvanizing or anodizing, whether used as a pretreatment, primer, intermediate coat, or finish coat.

2. The term "DFT" means minimum dry film thickness, without any negative tolerance.

C. The following surfaces shall not be coated:

1. Concrete, unless required by items on the concrete coating schedule below or the Drawings.

2. Stainless steel

3. Machined surfaces

4. Grease fittings

5. Glass

6. Equipment nameplates

7. Platform gratings, stair treads, door thresholds, and other walk surfaces, unless specifically indicated to be coated.

8. Platform gratings, stair treads, door thresholds, and other walk surfaces, unless specifically indicated to be coated.

D. The coating system schedules summarize the surfaces to be coated, the required surface preparation, and the coating systems to be applied. Coating notes on the Drawings are used to show or extend the limits of coating schedules, to show exceptions to the schedules, or to clarify or show details for application of the coating systems.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Submittals shall include the following information and be submitted at least 30 Days prior to commencing protective coating WORK:

1. Materials List: Eight copies of a coating materials list showing the manufacturer and the product number, keyed to the coating systems herein. The list shall be submitted prior to or at the time of submitting samples.

2. Manufacturer's Information: For each coating system to be used, the following data:

    a. Manufacturer's data sheet for each product proposed, including statements on the suitability of the material for the intended use.

    b. Technical and performance information that demonstrates compliance with the system performance and material requirements.

    c. Paint manufacturer's instructions and recommendations on surface preparation and application.

    d. Colors available for each product (where applicable).

    e. Compatibility of shop and field applied coatings (where applicable).

    f. Material Safety Data Sheet for each product proposed.

C. Samples

1. Samples of paint, finishes, and other coating materials shall be submitted on 8-1/2 inch by 11-inch sheet metal. Each sheet shall be completely coated over its entire surface with one protective coating material, type, and color.

2. Two sets of color samples to match each color selected by the ENGINEER from the manufacturer's standard color sheets. If custom mixed colors are indicated, the color samples shall be made using color formulations prepared to match the color samples furnished by the ENGINEER. The color formula shall be shown on the back of each color sample.

3. One 5 pound sample of each abrasive proposed to be used for surface preparation for submerged and severe service coating systems.

D. Experience Requirements of the Field Applicator:

1. Three references which verify that the coating CONTRACTOR has demonstrated successful application of the specified coating system in the past 3 years. Provide the size (area of coating), time of completion, name, the owner’s address and telephone number for each installation referenced.

2. A written statement from the CONTRACTOR stating that they are qualified and experienced in the application of the specified coating systems. The letter shall state the manufacturer and model number of mixing, heating, and pumping equipment to be used to apply the specified coating systems.

3. A written statement from the manufacturer certifying that the coating CONTRACTOR’s onsite foreman and each applicator performing WORK on the project has been trained and approved to apply the selected coating system.

4. CONTRACTOR shall provide SSPC QP 1 Certification or the manufacturer’s certification of the applicator for the specified coating system.

E. Experience Requirements of the Shop Applicator

1. NACE Coating Inspector Program certification documents for the person responsible for Quality Assurance/Quality Control at the facility. This person will be responsible for submitting inspection reports to the OWNER.

2. A copy of a typical Quality Assurance/Quality Control inspection report containing items listed in 3.18 of this Specification.

3. Three references which verify that the shop painting facility has demonstrated successful application of the specified coating systems in the past 3 years. Provide the structure name and size (area of coating), time of completion, the owner's name, address, and telephone number for each installation referenced.

4. The manufacturer shall provide written certification that the shop painting facility's supervisor and each applicator performing Work on the project have been trained and approved by the manufacturer to apply the selected coating system.

5. The manufacturer shall state whether or not it has verified that the CONTRACTOR is going to use the proper mixing, coating application, heating, and environmental control equipment for the specified coating products. Only heated plural component equipment shall be used for the 100% solids coating application. Equipment shall be capable of performing a ratio test.

6. The Shop Coating Applicator shall provide SSPC QP 3 Certification or the coating manufacturer's certification of the applicator for selected coating system.

1.3 SPECIAL CORRECTION OF DEFECTS REQUIREMENTS

A. Inspection: An inspection may be conducted during the eleventh month following completion of coating WORK. The CONTRACTOR and a representative of the coating material manufacturer shall attend this inspection. Defective WORK shall be repaired in accordance with these specifications and to the satisfaction of the OWNER. The OWNER may, by written notice to the CONTRACTOR, reschedule the inspection to another date within the one year correction period or may cancel the inspection altogether. The CONTRACTOR is not relieved of its responsibilities to correct defects, whether or not the inspection is conducted.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Suitability: The CONTRACTOR shall use suitable coating materials as recommended by the manufacturer. Materials shall comply with Volatile Organic Compound (VOC) limits applicable at the Site.

B. Material Sources: Where manufacturers and product numbers are listed, it is to show the type and quality of coatings that are required. If a named product does not comply with VOC limits in effect at the time of Bid opening, that product will not be accepted, and the CONTRACTOR shall propose a substitution product of equal quality that does comply. Proposed substitute materials will be considered as indicated below. Coating materials shall be materials that have a record of satisfactory performance in industrial plants, manufacturing facilities, and water and wastewater treatment plants.

C. Compatibility: In any coating system only compatible materials from a single manufacturer shall be used in the WORK. Particular attention shall be directed to

compatibility of primers and finish coats. If necessary, a barrier coat shall be applied between existing prime coat and subsequent field coats to ensure compatibility.

D. Containers: Coating materials shall be sealed in containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, and name of manufacturer, all of which shall be plainly legible at the time of use.

E. Colors: Colors and shades of colors of coatings shall be as indicated or selected by the ENGINEER. Each coat shall be of a slightly different shade to facilitate inspection of surface coverage of each coat. Finish colors shall be as selected from the manufacturer's standard color samples by the ENGINEER.

F. Substitute or "Or-Equal" Products

1. To establish equality under Section 01 60 00 - Products, Materials, Equipment and Substitutions, the CONTRACTOR shall furnish satisfactory documentation from the manufacturer of the proposed substitute or "or-equal" product that the material meets the indicated requirements and is equivalent or better in the following properties:

    a. Minimum and maximum recoat times

    b. Minimum and maximum cure time for immersion

    c. Abrasion resistance per ASTM D4060 using CS17 Wheel

    d. Maximum and minimum dry film thickness per coat

    e. Compatibility with other coatings

    f. Suitability for the intended service

    g. Resistance to chemical attack

    h. Temperature limitations during application and in service

    i. Type and quality of recommended undercoats and topcoats

    j. Ease of application

    k. Ease of repairing damaged areas

    l. Stability of colors

2. Protective coating materials shall be standard products produced by recognized manufacturers who are regularly engaged in production of such materials for essentially identical service conditions. When requested, the CONTRACTOR shall provide the ENGINEER with the names of not less than 10 successful applications of the proposed manufacturer's products that comply with these requirements.

3. If a proposed substitution requires changes in the WORK, the CONTRACTOR shall bear such costs involved as part of the WORK.

2.2 INDUSTRIAL COATING SYSTEMS

A. System 1 - Not Used

B. System 2 - Not Used

C. System 3 - Not Used

D. System 4 - Epoxy/Polyurethane

1. Materials

Primer type	rust-inhibitive, 2 component epoxy
VOC Content, max	285 g/L
Finish type	2 component aliphatic polyurethane
VOC Content, max	300 g/L
Demonstrated suitable for	ferrous surfaces, superior color and gloss retention, exceptional resistance to weathering, chemical fumes, and splash

2. Application and manufacturers

Prime Coat (DFT = 3 - 5 mils)	Finish Coat (DFT = 3 - 4 mils)	TOTAL SYSTEM DFT
PPG- Amerlock 400/2	**PPG- Amershield**	6 - 9 MILS
Carboline Carboguard 893	**Carboline Carbothane 134 HG (2 coats)**	
Devoe Devran 224V	**Devoe Dethane 379H**	
Tnemec Hi-Build Epoxoline II Series L69	**TNEMEC SERIES 750UVX**	
Sherwin Williams Macropoxy 646	**Sherwin Williams Hi-Solids Polyurethane**	

E. System 5 - Not Used

F. System 6 - Not Used

G. System 7 - Acrylic Latex

1. Material

Primer	Product, surface preparation, and DFT as recommended by manufacturer for the surface
Finish Type	Single component, water based acrylic latex, with fungicide
VOC Content, max	180 grams per gallon
Demonstrated suitable for	PVC piping, weather and mild chemical resistance, excellent color and gloss retention

2. Application and manufacturers

Finish (at least 2 coats required)	Total System DFT
PPG- Amercoat 220	primer plus 6 mils
Carboline Carbocrylic 3359	
Tnemec Series 1028 Enduratone	
Sherwin Williams Metalatex	
Devoe Devcryl 530	

H. System 8 - Epoxy, Equipment

1. Materials

Primer Type	2 component epoxy, recoatable up to one year
Demonstrated suitable for	Rust inhibitive, outstanding chemical, abrasion, and weathering resistance, resistance to splash, washdown, and condensation. Immersion capability is not required
VOC content, max	330
Finish Type	2 component epoxy, available in many colors
Demonstrated suitable for	Outstanding chemical, abrasion, and weathering resistance, resistance to splash, washdown, and condensation. Immersion capability is not required
VOC content, max	330

2. Application and manufacturers

Prime Coat (DFT = 4 to 6 mils)	FINISH COAT (DFT = 3 TO 4 MILS)	TOTAL SYSTEM DFT
PPG-Amerlock 400	**Amerlock 400**	7 to 10 mils
Tnemec Series L69	**Tnemec Series L69**	
Devoe Devran 224V	**Devran 224V**	
Carboline Carboguard 888	**Carboguard 888**	
Sherwin Williams Macropoxy 646	**S W Macropoxy 646**	

I. System 9 - Not Used

J. System 10 - Not Used

K. System 11 - Not Used

L. System 12 - Polyurethane, Fiber Glass

1. Materials

Primer Type	as recommended by manufacturer
Finish Type	2 component aliphatic polyurethane
Demonstrated suitable for	Fiberglass, superior color and gloss retention, resistance to acid and alkali splash, fumes, and severe weathering, no immersion
VOC content, g/L max	300

2. Application and manufacturers

Prime Coat (3 to 4 mils)	Finish Coats (4 to 6 mils)	Total System DFT
PPG- Amerlock 400	**Amershield**	7 to 10 mils
Tnemec Series 750 UVX	**Tnemec Series 750 UVX**	
Carboline Carbocrylic 120 (2 coats)	**Carbothane 134 HG (2 coats)**	
SHERWIN WILLIAMS MACROPOXY 646	**S-W Hi-Solids Polyurethane**	
DEVOE DEVRAN 224V	**Devoe Devthane 379H**	

2.3 SUBMERGED AND SEVERE SERVICE COATING SYSTEMS

A. System 100 - Amine Cured Epoxy

1. Material

Type	high build, amine cure epoxy
VOC content, g/L max	220
Demonstrated suitable for	steel, long term immersion in water and wastewater, resistant to corrosion, chemical fumes, good color retention
Certification	NSF 61 if in contact with potable water

2. Application and manufacturers

Products (3 coats or more)	**Total System DFT**

PPG- Amercoat 133	15 to 17 mils For non-submerged valves and other equipment, DFT = 10 to 12 mils
Carboline Carboguard 891HS	
International Bar-Rust 233H	
Tnemec Epoxoline Series L69	
Sherwin Williams Macropoxy 646 PW	

B. System 101 - Not used

C. System 102 - Polyamide Epoxy

1. Materials

Type	high build polyamide cure epoxy
VOC content, max, g/L	366
Demonstrated suitable for	long term immersion in water and wastewater, resistant to corrosion and chemical fumes, good color retention
Certification	NSF 61 if in contact with potable water

2. Application and manufacturers

Products (3 coats or more)	**Total System DFT**
PPG- Amercoat 370	11 - 13 mils
Tnemec Pota-Pox Series 20	
Carboline Carboguard 61	
Sherwin Williams Macropoxy 646 PW for water and Dura-Plate 235 for wastewater	
Devoe Bar-Rust 233H	

D. System 103 - Not Used

E. System 104 - Not Used

F. System 105 - Not Used

G. System 106 - Fusion Bonded Epoxy

1. Material

Type	100 percent solids fusion bond epoxy
Demonstrated suitable for	fluidized bed or electrostatic spray application, recommended for pumps, valves, pipe appurtenances, tanks, pipe hangers, flow meters, and hydrants
Certification requirement	NSF 61

2. Application in accordance with AWWA C213 and the following:

Product	Surface and DFT
3M Scotchkote 134 or 206N	Valves 12-mils
	All others 16-mils

H. System 107 - Not Used

I. System 108 - Not Used

J. System 109 - Not Used

K. System 110 - Not Used

L. System 111 - Not Used

2.4 SPECIAL COATING SYSTEMS

A. System 200 - PVC Tape: Prior to wrapping the pipe with PVC tape, the pipe and fittings first shall be primed using a primer recommended by the PVC tape manufacturer. After being primed, the pipe shall be wrapped with a 20-mil adhesive PVC tape, half-lapped, to a total thickness of 40 mils.

B. System 201 - Rich Portland Cement Mortar**:** Rich portland cement mortar coating shall have a minimum thickness of 1/8-inch, followed by enclosure in an 8-mil thick polyethylene sheet with all joints and edges lapped and sealed with tape.

C. System 202 - Not Used

D. System 203 - Not Used

E. System 204 - Not Used

F. System 205 - Polyethylene Encasement: Application of polyethylene encasement shall be in accordance with ANSI/AWWA C105 using Method C.

G. System 206 - Cement Mortar Coating**:** A 1-1/2-inch minimum thickness mortar coating reinforced with 3/4-inch galvanized welded wire fabric shall be provided. The cement mortar shall contain no less than one part Type V cement to 3 parts sand. The cement mortar shall be cured by a curing compound meeting the requirements of "Liquid Membrane Forming Compounds for Curing Concrete," ASTM C 309, Type II, white

pigmented, or by enclosure in an 8-mil thick polyethylene sheet with all edges and joints lapped by at least 6-inches.

H. System 207 - Not Used

I. System 208 - Aluminum Metal Isolation

1. Material

Type	high build polyamide epoxy with chemical and abrasion resistance
Demonstrated suitable for	concrete and aluminum substrates, to isolate aluminum from contact with concrete and the resulting chemical degradation
VOC content, max	250

2. Application and manufacturers

Coating (DFT = 16 - 20 mils)
PPG- Sigma, Novoguard 840
Sherwin Williams Macropoxy 646
Tnemec Epoxoline Series L69
Carboline 890
Devoe Bar-Rust 231

J. System 209 - Not Used

K. System 210 - Not Used

PART 3 --

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall require the protective coating manufacturer to furnish a qualified technical representative to visit the Site for technical support as may be necessary to resolve field problems.

3.2 WORKMANSHIP

A. Skilled craftsmen and experienced supervision shall be used on coating WORK.

B. Coating shall be done in a workmanlike manner so as to produce an even film of uniform thickness. Edges, corners, crevices, and joints shall receive special attention to insure thorough surface preparation. The finished surfaces shall be free from runs, drops, ridges, waves, laps, brush marks, and variations in color, texture, and finish. The hiding shall be so complete that the addition of another coat would not increase the hiding. Special attention shall be given so that edges, corners, crevices, welds, and similar areas receive

a film thickness equivalent to adjacent areas, and installations shall be protected by the use of drop cloths or other precautionary measures.

C. Damage to other surfaces resulting from the WORK shall be cleaned, repaired, and refinished to original condition.

3.3 STORAGE, MIXING, AND THINNING OF MATERIALS

A. Manufacturer's Recommendations**:** Unless otherwise indicated, the coating manufacturer's printed recommendations and instructions for thinning, mixing, handling, applying, and protecting its coating materials, for preparation of surfaces for coating, and for other procedures relative to coating shall be strictly observed.

B. Coating materials shall be used within the manufacturer's recommended shelf life.

C. Storage and Mixing: Coating materials shall be stored under the conditions recommended by the Product Data Sheets, and shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Coatings from different manufacturers shall not be mixed together.

3.4 PREPARATION FOR COATING

A. General: Surfaces to receive protective coatings shall be prepared as indicated prior to application of coatings. The CONTRACTOR shall examine surfaces to be coated and shall correct surface defects before application of any coating material. Marred or abraded spots on shop-primed and on factory-finished surfaces shall receive touch-up restoration prior to any field coating application. Surfaces to be coated shall be dry and free of visible dust.

B. Protection of Surfaces Not to be Coated: Surfaces that are not to receive protective coatings shall be protected during surface preparation, cleaning, and coating operations.

C. Hardware, lighting fixtures, switch plates, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not to be painted shall be removed, masked, or otherwise protected. Drop cloths shall be provided to prevent coating materials from falling on or marring adjacent surfaces. The working parts of mechanical and electrical equipment shall be protected from damage during surface preparation and coating operations. Openings in motors shall be masked to prevent entry of coating or other materials.

D. Care shall be exercised not to damage adjacent WORK during blasting operations. Spraying shall be conducted under carefully controlled conditions. The CONTRACTOR shall be fully responsible for and shall promptly repair any and all damage to adjacent WORK or adjoining property occurring from blasting or coating operations.

E. Protection of Painted Surfaces: Cleaning and coating shall be coordinated so that dust and other contaminants from the preparation process will not fall on wet, newly-coated surfaces.

3.5 ENVIRONMENTAL REQUIREMENTS

A. No coating work shall be performed under the following conditions:

1. Surface or ambient temperatures exceed the manufacturer’s recommended maximum or minimum allowable.

2. Dust or smoke laden atmosphere.

3. Damp or humid conditions, where the relative humidity is above the manufacturer's maximum allowable.

4. Substrate and ambient temperatures are less than 5°F above the dew point and are decreasing. Dew point shall be measured by use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce, Weather Bureau psychrometric tables. Elcometer 319 Dew Point meter or equal may also be used.

5. Ambient temperature that is expected to drop below 50°F or less than 5°F above the dew point within 8 hours after application of coating.

3.6 SURFACE PREPARATION STANDARDS

A. The following referenced surface preparation specifications of the Steel Structures Painting Council shall form a part of this specification:

1. Solvent Cleaning (SSPC SP 1): Removal of oil, grease, soil, salts, and other soluble contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.

2. Hand Tool Cleaning (SSPC SP 2): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by hand chipping, scraping, sanding, and wire brushing.

3. Power Tool Cleaning (SSPC SP 3): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by power tool chipping, descaling, sanding, wire brushing, and grinding.

4. White Metal Blast Cleaning (SSPC SP 5/NACE 1): Removal of all visible rust, oil, grease, soil, dust, mill scale, paint, oxides, corrosion products and foreign matter by blast cleaning.

5. Commercial Blast Cleaning (SSPC SP 6/NACE 3): Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 33 percent of each square inch of surface area.

6. Brush-Off Blast Cleaning (SSPC SP 7/NACE 4): Removal of all visible oil, grease, soil, dust, loose mill scale, loose rust, and loose paint.

7. Near-White Blast Cleaning (SSPC SP 10/NACE 2): Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 5 percent of each square inch of surface area.

8. Power Tool Cleaning to Bare Metal (SSPC 11) When viewed without magnification, the surface shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter. Slight residues of rust and paint may be left in the lower portion of pits if the original surface is pitted. The surface profile shall not be less than 1 mil (25 microns).

9. Surface Preparation of Concrete (SSPC-SP 13/NACE 6): Removal of protrusions, laitance and efflorescence, existing coatings, form-release agents, and surface contamination by detergent or steam cleaning, abrasive blasting, water jetting, or

impact or power tool methods as appropriate for the condition of the surface and the requirements of the coating system.

3.7 FERROUS METAL SURFACE PREPARATION (UNGALVANIZED)

A. The minimum abrasive blasting surface preparation shall be as indicated in the coating system schedules included at the end of this Section. Where there is a conflict between these requirements and the coating manufacturer's printed recommendations for the intended service, the higher degree of cleaning shall apply.

B. The Shop Painting Facility shall use a minimum blast material mixture of 75% grit and 25% shot material to achieve the proper surface profile.

C. The Field Coating Applicator shall abrasive blast the shop coated surfaces per SSPC SP 7/NACE 4. The previously shop-painted surfaces shall be abraded prior to the application of the final coats. Special attention shall be given to uncoated steel weld joints, coating holdbacks, and bare metal.

D. Grease, oil, and welding fluxes shall be removed by wiping with MEK or naphtha cleaning or with trisodium phosphate detergent per SSPC SP 1.

E. All sharp edges shall be rounded or chamfered and all burrs, rust, scale, welding slag, and spatter shall be removed and the surface prepared by SSPC SP 2 hand tool cleaning, and SSPC SP 3 power tool cleaning.

F. The Contractor shall test the surfaces for soluble salts with the use of Chlor*Test as manufactured by Chlor*Rid International or approved equivalent. Any blasted surfaces shall be tested and shall have a maximum concentration of 5 micrograms per square centimeter ($\mu g/cm^2$). A test shall be conducted for every 100 square feet (ft2) of surface area to be coated at locations determined by the Inspector.

G. If the soluble salt test indicates chloride concentrations greater than those outlined in these Specifications, the Contractor shall use Chlor*Rid, as manufactured by Chlor*Rid International, in the water source during Water Cleaning to remove the salts from the substrate. A substrate’s surface preparation will be accepted once the soluble salt concentration is below the amounts outlined in these Specifications.

H. The type and size of abrasive shall be selected to produce a surface profile that meets the coating manufacturer's recommendation for the particular coating and service conditions.Abrasive shall not be reused unless an automated blasting system is used for surfaces that will be in non-submerged service. For automated blasting systems, clean oil-free abrasives shall be maintained. The abrasive mix shall include at least 50 percent grit.

I. The CONTRACTOR shall comply with the applicable federal, state, and local air pollution control regulations for blast cleaning.

J. Compressed air for air blast cleaning shall be supplied at adequate pressure from well-maintained compressors equipped with oil and moisture separators that remove at least 95 percent of the contaminants.

K. Surfaces shall be cleaned of dust and residual particles of the cleaning operation by dry air blast cleaning, vacuuming, or another approved method prior to painting.

L. Enclosed areas and other areas where dust settling is a problem shall be vacuum-cleaned and wiped with a tack cloth.

M. Damaged or defective coating shall be removed by the blast cleaning to meet the clean surface requirements before recoating.

N. If the required abrasive blast cleaning will damage adjacent WORK, the area to be cleaned is less than 100 square feet, and the coated surface will not be submerged in service, then SSPC SP 2 or SSPC SP 3 may be used.

O. Shop-applied coatings of unknown composition shall be completely removed before the indicated coatings are applied. Valves, castings, ductile or cast iron pipe, and fabricated pipe or equipment shall be examined for the presence of shop-applied temporary coatings. Temporary coatings shall be completely removed by solvent cleaning per SSPC SP 1 before the abrasive blast cleaning has been started.

P. Shop primed equipment shall be solvent-cleaned in the field before finish coats are applied.

3.8 FERROUS METAL SURFACE PREPARATION (GALVANIZED)

A. Galvanized ferrous metal shall be alkaline cleaned per SSPC SP 1 to remove oil, grease, and other contaminants detrimental to adhesion of the protective coating system, followed by brush off blast cleaning per SSPC SP 7/NACE 4.

B. Any high spots, sharp protrusions, and rough edges, such as the metal drip line, shall be smoothed to avoid paint film gaps in the areas of the high spots. Surfaces shall be hand tool cleaned per SSPC SP 2 and power tool cleaned per SSPC SP 3.

C. Pretreatment coatings of surfaces shall be in accordance with the printed recommendations of the coating manufacturer. Galvanized metals may be cleaned with suitable organic solvent such as a rust inhibitor or aqueous alkaline solution per ASTM D6386.

D. The surfaces of galvanized steel exposed to chemical splashing or within a wastewater head space shall be abraded per SSPC SP 11 or SP 7 prior to coating.

3.9 SURFACE PREPARATION OF FERROUS SURFACES WITH EXISTING COATINGS, EXCLUDING STEEL RESERVOIR INTERIORS

A. General: Grease, oil, heavy chalk, dirt, or other contaminants shall be removed by solvent or detergent cleaning prior to abrasive blast cleaning. The generic type of the existing coatings shall be determined by laboratory testing.

B. Abrasive Blast Cleaning: The CONTRACTOR shall provide the degree of cleaning indicated in the coating system schedule for the entire surface to be coated. If the degree of cleaning is not indicated in the schedule, deteriorated coatings shall be removed by abrasive blast cleaning to SSPC SP 6/NACE 3. Areas of tightly adhering coatings shall be cleaned to SSPC SP 7/NACE 4, with the remaining thickness of existing coating not to exceed 3-mils.

C. Incompatible Coatings: If coatings to be applied are not compatible with existing coatings the CONTRACTOR shall apply intermediate coatings per the manufacturer's recommendation for the indicated coating system or shall completely remove the

existing coating prior to abrasive blast cleaning. A small trial application shall be conducted for compatibility prior to painting large areas.

D. Unknown Coatings: Coatings of unknown composition shall be completely removed prior to application of new coatings.

E. Water Abrasive or Wet Abrasive Blast Cleaning: Where indicated or where Site conditions do not permit dry abrasive blasting for industrial coating systems due to dust or air pollution considerations, water abrasive blasting or wet abrasive blasting may be used. In both methods, paint-compatible corrosion inhibitors shall be used, and coating application shall begin as soon as the surfaces are dry. Water abrasive blasting shall be done using high pressure water with sand injection. In both methods, the equipment used shall be commercially produced equipment with a successful service record. Wet blasting methods shall not be used for submerged or severe service coating systems unless indicated.

3.10 PLASTIC, FIBER GLASS AND NONFERROUS METALS SURFACE PREPARATION

A. Plastic and fiber glass surfaces shall be sanded or brush off blast cleaned prior to solvent cleaning with a chemical compatible with the coating system primer.

B. Non-ferrous metal surfaces shall be solvent-cleaned SSPC SP 1 followed by sanding or brush-off blast cleaning SSPC SP 7/NACE 4.

C. Surfaces shall be clean and dry prior to coating application.

3.11 SHOP COATING REQUIREMENTS

A. Unless otherwise indicated, items of equipment or parts of equipment which are not submerged in service shall be shop-primed and then finish-coated in the field after installation with the indicated or selected color. The methods, materials, application equipment, and other details of shop painting shall comply with this Section. If the shop primer requires top coating within a specific period of time, the equipment shall be finish-coated in the shop and then be touched up after installation.

B. Items of equipment or parts and surfaces of equipment which are submerged or inside an enclosed hydraulic structure when in service, with the exception of pumps and valves, shall have surface preparation and coating performed in the field.

C. Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning all surfaces as necessary in accordance with SSPC SP 1 and SP 2. Damaged shop coating shall be cleaned in accordance with SSPC SP 3, Power Tool Cleaning, and recoated with the primer specified.

D. For every 500 square feet, or less, of steel surface blasted, the surface profile shall be tested with the use of Press-o-Film as manufactured by Testex, or other RP0287 approved equal, at locations to be determined by the Inspector. The replica tape thickness shall be measured using a dial micrometer manufactured by Testex, or other ASTM D4417 Type C approved equal. For each test area, one replica tape test shall be performed. For each test area, the three replica tape thickness values shall be recorded and must be within 10% of the coating manufacturer’s recommended profile. If the surface profile does not meet the manufacturer’s recommended profile, two additional tests will be performed within a 12-inch diameter of the initial test. If the values are not satisfactory, the Contractor shall reblast the affected areas.

E. The interior surfaces of steel water reservoirs, except for Paragraph A surfaces, shall have surface preparation and coating WORK performed in the field.

F. For certain pieces of equipment it may be undesirable or impractical to apply finish coatings in the field. Such equipment may include engine generator sets, equipment such as electrical control panels, switchgear or main control boards, submerged parts of pumps, ferrous metal passages in valves, or other items where it is not possible to obtain the indicated quality in the field. Such equipment shall be primed and finish-coated in the shop and touched up in the field with the identical material after installation. The CONTRACTOR shall require the manufacturer of each such piece of equipment to certify as part of its Shop Drawings that the surface preparation is in accordance with these specifications. The coating material data sheet shall be submitted with the Shop Drawings for the equipment.

G. For certain small pieces of equipment the manufacturer may have a standard coating system that is suitable for the intended service conditions. In such cases, the final determination of suitability will be made during review of the Shop Drawing submittals. Equipment of this type generally includes only indoor equipment such as instruments, small compressors, and chemical metering pumps.

H. Shop-painted surfaces shall be protected during shipment and handling by suitable provisions including padding, blocking, and the use of canvas or nylon slings. Primed surfaces shall not be exposed to the weather for more than 2 months before being top coated or less time if recommended by the coating manufacturer.

I. Damage to shop-applied coatings shall be repaired in accordance with this Section and the coating manufacturer's printed instructions.

J. The CONTRACTOR shall make certain that the shop primers and field topcoats are compatible and meet the requirements of this Section. Copies of applicable coating manufacturer's data sheets shall be submitted with equipment Shop Drawings.

3.12 APPLICATION OF COATINGS

A. The application of protective coatings to steel substrates shall be in accordance with SSPC PA1 - Paint Application Specification No. 1.

B. Cleaned surfaces and each coat shall be inspected prior to applying each succeeding coat. The CONTRACTOR shall schedule such inspection with the ENGINEER in advance.

C. Blast cleaned ferrous metal surfaces shall be painted before any rusting or other deterioration of the surface occurs. Blast cleaning shall be limited to only those surfaces that can be coated in the same day.

D. Coatings shall be applied in accordance with the manufacturer's instructions and recommendations and this Section, whichever has the most stringent requirements.

E. Special attention shall be given to edges, angles, weld seams, flanges, nuts and bolts, and other places where insufficient film thicknesses are likely to be present. CONTRACTOR shall use an independent stripe coat per SSPC PA Guide 11 for these areas. Particular care shall be used to ensure that the specified coverage is secured on the edges and corners of all surfaces.

F. Special attention shall be given to materials that will be joined so closely that proper surface preparation and application are not possible. Such contact surfaces shall be coated prior to assembly or installation.

G. Finish coats, including touch-up and damage repair coats shall be applied in a manner that will present a uniform texture and color matched appearance.

H. Coatings shall not be applied under the following conditions:

1. Temperatures exceeding the manufacturer's recommended maximum and minimum allowable.

2. Dust or smoke laden atmosphere.

3. Damp or humid weather.

4. Substrate or air temperature is less than 5 degrees F above the dew point.

5. Air temperature is expected to drop below 40 degrees F or less than 5 degrees F above the dew point within 8 hours after application of coating.

6. Wind conditions are not calm.

I. Dew point shall be determined by use of a sling psychrometer in conjunction with U.S. Dept. of Commerce, Weather Bureau psychometric tables.

J. Unburied steel piping shall be abrasive blast cleaned and primed before installation.

K. Finish coats shall be applied after concrete, masonry, and equipment installation is complete, and the working areas are clean and dust free.

3.13 CURING OF COATINGS

A. The CONTRACTOR shall maintain curing conditions in accordance with the conditions recommended by the coating material manufacturer or by this Section, whichever is the most stringent, prior to placing the completed coating system into service.

B. In the case of enclosed areas, forced air ventilation, using heated air if necessary, may be required until the coatings have fully cured.

3.14 IDENTIFICATION OF PIPING

A. Identification of piping shall be in accordance with Section 40 05 02 - Piping Identification Systems.

B. Every valve or connection, where it may be possible for a worker to be exposed to a hazardous substance, shall be labeled.

3.15 SHOP AND FIELD INSPECTION AND TESTING

A. General: The CONTRACTOR shall give the ENGINEER a minimum of 3 Days advance notice of the start of any field surface preparation or coating application, and a minimum of 7 Days advance notice of the start of any surface preparation activity in the shop.

B. Such WORK shall be performed only in the presence of the ENGINEER, unless the ENGINEER has granted prior approval to perform such WORK in its absence.

C. Inspection by the ENGINEER, or the waiver of inspection of any particular portion of the WORK, shall not relieve the CONTRACTOR of its responsibility to perform the WORK in accordance with these Specifications.

D. Scaffolding shall be erected and moved to locations where requested by the ENGINEER to facilitate inspection. Additional illumination shall be furnished on areas to be inspected.

E. Inspection Devices: The CONTRACTOR shall furnish inspection devices in good working condition for the detection of holidays and measurement of dry film thicknesses of coatings. Dry-film thickness gauges shall be made available for the ENGINEER's use while coating is being done, until final acceptance of such coatings. The CONTRACTOR shall furnish the services of a trained operator of the holiday detection devices until the final acceptance of such coatings. Holiday detection devices shall be operated only in the presence of the ENGINEER.

F. Holiday Testing: The CONTRACTOR shall test for continuity all coated ferrous surfaces inside a steel reservoir, other surfaces that will be submerged in water or other liquids, surfaces that are enclosed in a vapor space in such structures, and surfaces coated with any of the submerged and severe service coating systems. Areas that contain discontinuities shall be marked and repaired or recoated in accordance with the coating manufacturer's printed instructions and then be retested.

1. Coatings with thickness exceeding 20-mils total DFT: Pulse-type holiday detector such as **Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20,** or equal shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the required coating thickness.

2. Coatings with thickness of 20-mils or less total DFT: **Tinker & Rasor Model M1** non-destructive type holiday detector, **K-D Bird Dog,** or equal shall be used. The unit shall operate at less than 75 volts. For thicknesses between 10- and 20-mils, a non-sudsing type wetting agent, such as **Kodak Photo-Flo** or equal, shall be added to the water prior to wetting the detector sponge.

G. Film Thickness Testing: On ferrous metals, the dry film coating thickness shall be measured in accordance with the SSPC Paint Application Specification No. 2 using a magnetic type dry film thickness gauge such as **Mikrotest Model FM, Elcometer Model 111/1EZ,** or equal. Each coat shall be tested for the correct thickness. No measurements shall be made until at least 8 hours after application of the coating. On non-ferrous metals and other substrates, the coating thicknesses shall be measured at the time of application using a wet film gauge.

H. Surface Preparation: Confirm proper surface profile with Testex Press-O-Film replica tape in accordance with NACE RP0287-02.

3.16 Coating System Schedule, Ferrous Metal - Not Galvanized

	Item	**Surface Prep.**	**System No.**
FM-1	All surfaces indoors and outdoors, exposed or covered,	Commercial blast cleaning SSPC SP	(4) epoxy/ polyurethane

	except those included below.	6/NACE 3	
FM-6	Buried small steel pipe.	Removal of dirt, grease, oil	(200) PVC tape
FM-7	Where indicated, ferrous surfaces in water passages of all valves (except 48” butterfly) 2-inch size and larger, exterior surfaces of submerged valves.	White metal blast cleaning SSPC SP 5/NACE 1	(102) polyamide epoxy
FM-8	Where indicated, ferrous surfaces in water passages and submerged surfaces of all pumps which have discharge size of 4 inches or larger.	White metal blast cleaning SSPC SP 5/NACE 1	(100) amine cure epoxy
FM-9	Ferrous surfaces of sleeve couplings and 48” butterfly valve.	Solvent cleaning SSPC SP 1, followed by white metal blast cleaning SSPC-SP 10/NACE 2	(106) fusion bond epoxy
FM-11	Buried surfaces that are not indicated to be coated elsewhere.	Near white metal blast cleaning SSPC SP 10/NACE 2	(100) amine cure epoxy

FM-16	Surfaces of indoor equipment, not submerged	Commercial blast cleaning SSPC SP 6/NACE 3	(8) epoxy, equipment
FM-18	Buried pipe couplings, valves, fittings, and flanged joints (where piping is plastic).	Removal of dirt, grease, oil	(201) rich portland cement mortar
FM-19	Buried pipe couplings, valves, and flanged joints (where piping is ductile or cast iron, not tape-coated), including factory-coated surfaces.	As specified by reference specification	(205) polyethylene encasement
FM-20	Buried pipe couplings, valves, and flanged joints (where piping is mortar-coated steel or reinforced concrete), including factory-coated surfaces.	Removal of dirt, grease, oil	(206) cement mortar coating

3.17 Coating System Schedule, Ferrous Metal - Galvanized: Pretreatment coatings, barrier coatings, or washes shall be applied as recommended by the coating manufacturer. All galvanized surfaces shall be coated except for the following items which shall be coated only if required by other Sections: (1) Floor gratings and frames, (2) Handrails, (3) Stair treads, (4) Chain link fencing and appurtenances.

	Item	**Surface Prep.**	**System No.**
FMG-1	All exposed surfaces indoors and outdoors, except those included below.	Solvent cleaning SSPC SP 1	(4) epoxy/ polyurethane
FMG-3	Buried small steel pipe.	Removal of dirt, grease, oil	(200) PVC tape
FMG-4	Surfaces buried or submerged in water or wastewater, including all surfaces lower than two feet above high water level and all surfaces inside enclosed hydraulic structures and vents.	Solvent cleaning SSPC SP 1 followed by brush-off grade blast cleaning SSPC SP 7/NACE 4	(100) amine cure epoxy

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3.18 COATING SYSTEM SCHEDULE, NON-FERROUS METAL, PLASTIC, FIBER GLASS

A. Where isolated non-ferrous parts are associated with equipment or piping, the CONTRACTOR shall use the coating system for the adjacent connected surfaces. Do not coat handrails, gratings, frames or hatches. Only primers recommended by the coating manufacturer shall be used.

	Item	Surface Prep.	System No.
NFS-1	All exposed surfaces, indoors and outdoors, except those included below.	Solvent cleaned SSPC SP 1	(4) epoxy/polyurethane
NFS-2	Chlorination room, chlorine storage room.	Solvent cleaned SSPC SP 1	(100) amine cure epoxy
NFS-3	Aluminum surfaces in contact with concrete, or with any other metal except galvanized ferrous metal.	Solvent cleaned SSPC	(208) aluminum metal isolation
NFS-4	Polyvinyl chloride plastic piping, indoors and outdoors, or in structures, not submerged.	Solvent cleaned SSPC	(7) acrylic latex
NFS-5	Fiber glass surfaces.	Per paragraph 3.10	(12) polyurethane, fiber glass
NFS-6	Buried non-ferrous metal pipe.	Removal of dirt, grease, oil	(200) PVC tape

END OF SECTION

SECTION 09 96 12- POLYETHYLENE TAPE WRAPPING FOR PIPE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide a prefabricated, cold-applied, multilayer polyethylene tape coating system on pipe, complete and in place, in accordance with the Contract Documents.

B. Except as described in this Section, the coating system shall be in accordance with AWWA C214 for straight pipe sections and AWWA C209 for fittings, specials, and joints.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. References herein to "SSPC Specifications" or "SSPC" shall mean the published standards of the Society of Protective Coatings.

B. Commercial Standards

AWWA C200	Steel Water Pipe 6 inches and larger
AWWA C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines

1.3 CONTRACTOR SUBMITTALS

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

B. Coating Materials List: A list of the tape coating materials that indicates the manufacturer, product numbers, technical information, and thickness of the materials.

C. Samples: Samples of the materials for testing by the ENGINEER. Each sample shall be clearly identified for catalog number, size, color, and other information required for testing.

1.4 QUALITY ASSURANCE

A. General: Furnish the ENGINEER a minimum of 7 Days advance notice of the start of any shop coating and a minimum of 3 Days advance notice for field coating.

B. Unless the ENGINEER has granted prior approval, coating WORK shall be performed in the presence of the ENGINEER.

C. Inspection Devices: The CONTRACTOR shall furnish inspection devices that are calibrated and in good working condition for the detection of holidays and measurement of coating film thicknesses.

D. Inspection: The CONTRACTOR shall retain the services of trained technicians to test the coating system in the shop and field and prepare reports. As a minimum, the tests shall include holiday detection and coating film thickness.

E. Tape application to straight pipe sections shall be monitored using instrumentation devices that continuously measure and record the tape width neckdown and the tape temperature.Each tape application station shall be equipped with the instrumentation devices. The tape tensions and temperatures shall be controlled using the data obtained from the instrumentation devices.

F. Manufacturer Representative: The CONTRACTOR shall require the tape material manufacturer to furnish a qualified factory technical representative to visit the pipe coating shop for technical support at the beginning of the tape coating operation and as may be necessary to resolve shop or field problems.

G. Holiday Detection: Prior to application of the first layer of mechanical protection tape, the inner layer tape shall be electrically tested for coating flaws with a holiday detector approved by the ENGINEER. Holidays shall be immediately repaired and retested before application of the first layer of mechanical protection tape.

H. Immediately before the coated pipe is lowered into the trench, the CONTRACTOR shall provide a visual and holiday inspection of the coating on the underside of the pipe.

PART 2 -- PRODUCTS

2.1 COATING SYSTEMS

A. Straight pipe sections shall be provided with a multi-layer polyethylene tape system as described below.

1. Liquid Adhesive layer.

2. Filler tape, extruded butyl rubber compound compatible with the primer and tape.

3. Weld stripping tape, if required (25-mils).

4. Inner layer, corrosion protection tape (20-mils).

5. Middle layer, mechanical protection tape (30-mils).

6. Outer layer, mechanical protection tape (30-mils) with ultraviolet light stabilizers.

7. Total system thickness shall be at least 80-mils (nominal).

8. Coating materials shall be supplied by a single manufacturer, whose products have a successful application and service history on pipe fabricated in accordance with AWWA C200.

9. The coating system materials shall be as manufactured by Berry Plastics Corrosion Protection Group (Polyken) or equal, as itemized below:

Liquid Adhesive	1019 or 1033A or 1039 or HM 1100
Filler tape	939
Weld stripping tape	933-25 black, 6” minimum width

Inner layer tape	989-20 black, 12” maximum width
Middle layer tape	955-30 gray, 12” maximum width
Outer layer tape	956-30 white, 12” maximum width

B. Fittings, specials, and field joints shall be provided a 3 layer polyethylene tape system as described below:

1. Liquid Adhesive layer

2. Filler tape, extruded butyl rubber compound compatible with the primer and tape.

3. Inner layer, corrosion protection tape (50-mils).

4. Outer layer, mechanical and ultraviolet light protection tape (30-mils).

5. Total system thickness shall be at least 80-mils.

6. The coating materials shall be supplied by the same manufacturer as the materials for straight pipe.

7. The coating system materials shall be as manufactured by Berry Plastics Corrosion Protection Group (Polyken) or equal, as itemized below:

Liquid Adhesive	1027
Filler tape	939
Inner layer tape	930-50 black or 932-50
Outer layer tape	955-30 white or 905-30 white

8. The inner and outer layer tapes are assumed to be applied with a 1” overlap. Other configurations, such as 930-35 can be applied in a “half lapped” configuration to achieve the over all system required thickness.

C. Storage of Materials: Materials shall be stored within the temperature ranges indicated for application, using heated storage areas if necessary. Tape shall be stored at a minimum temperature of 70 degrees F. Not more than 85 degrees on the 989-20 and not more than 110 degrees F on the 955 and the 956 middle and outer layer .The liquid Adhesive 1027 1033A or 1039 should not be heated higher than 70 degrees F

PART 3 -- EXECUTION

3.1 TAPE APPLICATION

A. Tape coating materials shall be applied in accordance with this Section, the product application instructions of the tape manufacturer, and the field technical support instructions from the manufacturer.

3.2 WELD SURFACE PREPARATION

A. To provide for an effective, long term bond between the tape coating system and the substrate, the following pipe weld surface preparation shall be provided.

1. Weld surfaces with a reinforcement greater than 1/32-inch and all longitudinal and coil splice welds shall be ground to provide a smooth surface with a reinforcement not exceeding 1/32-inch. The resulting weld surface shall have a cross-section shape that is free of discontinuities, abrupt changes in curvature, with no ridges or valleys that may promote bridging or disbondment of the tape from the substrate.

2. Weld Stripping Tape: Weld stripping tape, 6-inches wide, shall be used if any of the following conditions are present.

a. If the CONTRACTOR elects to use stripping tape in lieu of grinding or part of the grinding required above. In such a case, the weld reinforcement shall not exceed 3/32-inch, and the weld surface shall have a cross-section shape that is free of discontinuities, abrupt changes in curvature, with no ridges or valleys that may promote bridging or disbondment of the tape from the substrate.

b. If the initial pipe sections taped have indications that the inner tape layer is not bonding completely to the pipe at the welds.

c. If the tape bond to the welds or adjacent surfaces is less than the tape bond to the pipe surface away from the welds.

3. Welds that have any of the following require no additional preparation:

a. A reinforcement less than 1/32-inch.

b. A cross-section slope that is free of discontinuities and abrupt changes in curvature.

c. No ridges or valleys that may promote bridging or disbondment of the tape from the substrate.

4. The tape shall be applied with the center of the tape at the weld.

3.3 PIPE SURFACE PREPARATION

A. Surfaces to be coated shall be detergent cleaned in accordance with SSPC-SP1 prior to abrasive blasting.

B. Burrs, sharp edges, and weld splatter shall be removed prior to abrasive blasting.

C. Immediately before application of the Liquid Adhesive, abrasive blasting shall be performed using sand, metallurgical slag, or a combination of steel grit and shot to

produce a surface in conformance with SSPC-SP6. Steel grit shall comprise at least 60 percent of the working mix of abrasive, if a centrifugal wheel abrasive blaster is used. The prepared surface shall be a minimum of 1.5 mils and no greater than 3.0 mils.

D. Abrasive blasting and liquid adhesive application shall be done when the substrate surface is at least 5 degrees F above the dew point. Abrasive blasting, liquid adhesive, and inner layer tape application shall be done during the same working day for each pipe section.

3.4 PIPE END PREPARATION

A. Coating cut-backs at the pipe ends shall be 6-inches, with the cuts parallel to the pipe ends. Exposed substrate surfaces shall be protected with a storage primer applied immediately after taping and before flash rusting of the surface.

B. Spiral or longitudinal pipe welds within 2-feet of the pipe ends shall be ground flush prior to abrasive blast cleaning.

C. Pipe ends that will be connected with sleeve-type couplings shall be epoxy coated for immersion service in accordance with Section 09 96 00 – Protective Coating. The cut-backs shall be greater than 6-inches at couplings to provide clearance between the coupling and tape.

3.5 APPLICATION OF TAPE

A. Pipe shell temperature shall be maintained within a range of 45 degrees F to 100 degrees F during application of the tape system.

B. Inner layer tapes shall be maintained at a minimum temperature of 70 degrees F during application. Middle and outer layer tapes shall be maintained at a minimum temperature of 90 degrees F to 110 degrees F during application.

C. Tape application tension shall be maintained at a value that produces a tape width reduction equal to 1.0 to 2.0 percent of the tape width during application, as recommended by the tape manufacturer. This width reduction shall be maintained simultaneously with the minimum tape temperature.

D. At the point of tape application, all tape, including weld stripping tape, shall be pressed onto the pipe with a pressure roller that maintains a constant pressure. Enough pressure shall be used to fully bond the tape at welds.

E. Filler tape shall be used at lap joints, weld step-downs, and other discontinuities.

F. The tape application equipment and materials shall result in a fully bonded tape coating system, without blisters, voids, wrinkles or any areas that have a lack of bond to the pipe.

G. Succeeding layers of tape shall be applied so that the minimum overlap separation shall be 25% of the roll width.

H. Before tape application, the liquid adhesive shall be dried sufficiently so that the liquid adhesive is in a dry condition.

I. Liquid Adhesive shall be applied while it is in a temperature range of 50 to 70 degrees F degrees F, using airless spray equipment and a drum agitator. The liquid adhesive application shall be of uniform thickness on pipe surfaces.

3.6 REPAIR PATCHES

A. Repair patches shall be applied by wrapping tape completely around the pipe, using the tape system for joints.

3.7 STORAGE AND SHIPMENT

A. Pipe shall be square-stacked on padded supports or racks. Lifting equipment shall be padded and wide fabric slings shall be used. To the extent possible, the coated pipe shall be handled from the cut-back ends.

B. Tie down devices shall be padded where in contact with the pipe.

3.8 TAPE APPLICATION TO FITTINGS, SPECIALS, AND PIPE JOINTS

A. Filler tape shall be used to fill voids on fittings, specials, welds, and pipe joints.

B. Bell and spigot joints, lap joints, and other locations where voids will otherwise exist shall be provided specially shaped, filler tape applied after the liquid adhesive has been applied.

C. Field pipe joints shall be prepared as required by the paragraph above entitled "Pipe Surface Preparation," except that shop blasted surfaces that have been coated with a storage primer may be power tool cleaned instead of abrasive blast cleaned. The power tool cleaning shall be done in accordance with SSPC-SP2. Pipe ends not effectively protected with a storage primer shall be abrasive blasted to SSPC-SP6.

END OF SECTION

SECTION 10 14 00 – BUILDING SIGNAGE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide building signage and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCES

A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Americans with Disabilities Act (ADA): ADA Accessibility Guidelines (ADAAG).

C. Building Code: Refer to the Drawings to determine which Building Code applies. The applicable Building Code, defined by the Drawings, is referred to herein as “the CODE.”

D. National Fire Protection Association (NFPA):

NFPA 704 Identification of the Hazards of Materials for Emergency Response

E. Occupational Safety and Health Administration (OSHA).

1.3 CONTRACTOR SUBMITTALS

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

B. Literature: Manufacturer’s specifications, technical data, installation methods, and maintenance instructions, and the following:

1. Manufacturer’s full range color charts, indicating custom color availability for color selection by OWNER.

C. Warranty: Submit a copy of the warranty.

D. Certifications:

1. Certification by the building signage Manufacturer that the building signage provided is suitable for, and compatible with, the required installation.

2. Certification by the building signage Manufacturer that the building signage provided is suitable for, and compatible with, the substrates and surfaces indicated.

3. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated.

4. When requested by the ENGINEER, furnish other certifications as may be required to demonstrate compliance with the Contract Documents.

E. Shop Drawings: Complete Shop Drawings showing location and detail of installation.

1. Shop Drawings shall be drawn to sufficient scale and shall include dimensions, show elevations and details of construction of each building signage type, schedule of building signage, mounting details, location and installation requirements, thickness of materials, joints, provisions for expansion and contraction, connections, accessories, and trim.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: Building signage shall be provided by a single Manufacturer, unless otherwise indicated.

B. Manufacturer Qualifications:

1. Building signage Manufacturer shall have a minimum of 10 years of building signage manufacturing experience.

2. Building signage Manufacturers shall have the ability to print signs in Spanish.

3. Manufacturers without these qualifications will not be accepted.

1.5 SPECIAL WARRANTY PROVISIONS

A. Furnish Manufacturer's 15-year written warranty to cover defects in materials, products, and manufacturing workmanship.

1. Warranty shall include coverage against chipping, fading, rusting, shattering, or peeling.

B. Warranties shall be non-prorated for the entire warranty period.

C. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Building signage shall be recommended by the Manufacturer for the installation indicated.

B. Building signage shall be suitable for, and compatible with, the required installation.

C. Building signage shall be suitable for, and compatible with, the substrates and surfaces indicated.

2.2 RESTRICTIVE/CAUTION SIGNS

A. Signs shall be **SetonUltraTuff** by **Seton**, Branford, Connecticut, or approved equal.

B. Signs shall be constructed of a printed polyester film permanently bonded to a rigid fiberglass panel and over-laminated with **Tedlar** by **Seton**, or approved equal, and a total thickness of 0.11-inch (2.8 mm) minimum.

C. Signs shall be 14-inches (356 mm) wide by 10-inches (254 mm) tall in rounded corners. Color of signs and letters shall be in accordance with OSHA standards. All other

aspects of the Restrictive/Caution Signs shall be in accordance with OSHA standards. If OSHA standards do not apply, the color shall be red with white letters, 1-inch (25 mm) high.

D. Signs shall be wall and door surface mounted per Manufacturer standard. Signs shall be mounted as scheduled, as recommended in writing by the Manufacturer, and as approved by the ENGINEER.

E. Sign sizes shall be adjusted to suit the number of letters in each sign with a 1 1/2-inch (38.1 mm) minimum border all around. Two lines are permitted. Center justify the letters.

2.3 HAZARD IDENTIFICATION SYSTEM

A. System shall be manufactured by **Seton**, Branford, Connecticut, or approved equal.

1. System shall confirm to NFPA 704.

2. System shall use a diamond-shaped symbol divided into four smaller diamonds.

a. Health hazard diamond (left): blue background with a rating number in contrasting color.

b. Flammability hazard diamond (top): red background with a rating number in contrasting color.

c. Instability hazard diamond (right): yellow background with a rating number in contrasting color.

d. Special hazard diamond (bottom): white background with a rating number in contrasting color.

3. Colors used for the diamonds shall provide an adequate contrast so that the rating numbers are easily identified.

4. Signs mounted on walls and doors shall be high performances plastic signs.

5. Signs adhered to drums and containers shall be vinyl.

6. Unless otherwise noted, exterior signs shall be a minimum of 15-inches (381 mm) by 15-inches (381 mm) and interior signs shall be a minimum of 10-inches (254 mm) by 10-inches (254 mm)

PART 3 -- EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in Manufacturer’s original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.

B. Store materials carefully in accordance with the Manufacturer’s written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.

C. Handle materials in strict accordance with Manufacturer's written instructions.

3.2 LOCATIONS

A. Signage shall be installed at the locations indicated or as otherwise required by the CODE, ADAAG, NFPA 704, and OSHA. Where a conflict occurs between the requirements of this Section and the references herein, the more stringent shall apply, as directed by the ENGINEER.

B. Where not indicated, signs shall be installed as directed by the ENGINEER.

C. Signs shall be mounted 60-inches (1520-millimeters) above the floor, unless otherwise indicated.

3.3 PROJECT CONDITIONS

A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.

B. Protect surrounding WORK from damage that may result from operations under this Section.

3.4 INSPECTION

A. The CONTRACTOR shall be totally responsible for the proper performance and completion of the WORK under this Section.

B. Systems and components shall be inspected before installation.

1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.

2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.

C. The CONTRACTOR shall verify dimensions, tolerances, and method of attachment with adjacent WORK.

1. Examine substrates, areas, and conditions where building signage will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed building signage.

a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other WORK for the installation of building signage and appurtenances. Coordinate delivery with other WORK to avoid delay.

2. Notify the ENGINEER in writing of conditions detrimental to the proper and timely completion of the WORK. Do not proceed with the WORK until unsatisfactory conditions have been corrected in an acceptable manner.

3. Commencement of the installation by the CONTRACTOR shall indicate CONTRACTOR'S acceptance of the substrate, areas, and conditions.

3.5 PREPARATION

A. Sequence installation properly with the installation and protection of other WORK, so that neither will be damaged by the installation of the other.

3.6 INSTALLATION

A. Installation shall comply with the requirements of the Contract Documents, with applicable references, with the requirements of the CODE, NFPA 704, OSHA, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the ENGINEER.

B. The CONTRACTOR shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.

C. The CONTRACTOR shall provide separation of dissimilar materials to ensure no galvanic action occurs.

D. Horizontal lines shall be level, and vertical lines shall be plumb.

E. The CONTRACTOR shall block and reinforce walls as required to support building signage, and appurtenances.

3.7 CLEANING, FINISHING, AND PROTECTION

A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.

1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the CONTRACTOR.

2. Residue shall not be left on any surfaces.

B. Upon completion of the installation, building signage and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the ENGINEER.

1. Cleaning shall be performed again immediately prior to acceptance of the WORK, when directed by the ENGINEER.

2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.

C. Building signage shall be protected from damage from subsequent construction operations.

D. The CONTRACTOR shall make adjustments required until accepted.

E. The CONTRACTOR shall remove scratches and blemishes to the satisfaction of the ENGINEER.

F. Damaged or defective items shall be removed and replaced at the direction of the ENGINEER.

G. When building signage WORK is completed, remove unused materials, containers, and equipment, and clean the Site of building signage debris.

3.8 RESTRICTIVE/CAUTION SIGN SCHEDULE

Quantity	Sign Wording	Location
4	EXIT	• Locate a ladders • Others to be located by the ENGINEER.

END OF SECTION

SECTION 13 00 00 – HEATING SYSTEM

PART 1 -- GENERAL

1.1 SUMMARY

A. Furnish all labor, material, equipment, controls, and incidentals required to install and commision a complete intake heating system ready for operation as shown on the Drawings and as specified herein.

B. This Work includes the manufacture, and installation of heated cone inserts for the intake cones on the 60” intake structure and heating collers as shown on the Drawings. It includes the installation of an electric cable through the 60” intake pipe from the shore to the cones at the lake end, installation of electric cable to Shorewell #3, and associated electrical modifications. The manufacture will be responsible for provided system design and integration of the complete heating system.

C. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work. The CONTRACTOR shall be solely responsible for the provision of any and all equipment, materials and personnel necessary to support the Work required for the heating system installation as described in the Contract Documents, and to provide safety equipment as needed.

D. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.

1. Section 01 10 00 – Summary of Work.
2. Section 01 14 00 – Construction Constraints
3. Section 01 29 00 – Measurement and Payment
4. Section 26 00 00 – Electrical Work, General.
5. Section 26 01 26 – Electrical Tests.
6. Section 26 05 15 – Industrial Control Panels.
7. Section 26 05 19 – Wire and Cabling.
8. Section 26 12 16 – Panelboards and General Purpose Type Transformers

E. REFERENCES

1. ASTM International (ASTM).
2. American Water Works Association (AWWA).
3. NACE International (NACE).
4. National Electrical Code (NEC).

5. National Electrical Manufacturer's Association (NEMA).

6. Underwriters' Laboratories, Inc. (UL).

1.2 SYSTEM DESCRIPTION

A. The 60-Inch Intake Heating System is intended to minimize the accululation and formation of ice on the the intake inlet cones and piping during cold-weather conditions. The system will accomplish this using effective combinations of multiple electrical resistance heating elements to raise the surface temperature of critical sections of the intake structure such that ice formation and adhesion is prevented.

B. The system shall include methods to monitor intake water temperature and automatically adjust the power output to the heating elements, to control ice formation.

C. The System shall include all components to accomplish the Work including, but not limited to, the following:

1. Intake Heating System Control Panel.

2. Intake Heating System Power Transformer Panel

3. Electrical cables and connector couplings. Connector couplings shall be designed to allow for field disassembly and reconnection for future maintenance and replacement. No couplings for underwater connections. Enough cable must be provided, spooled, and secured, to allow for all connections to be made in the dry above the water surface, using water-tight splices. (future re-connections can by made by cutting and resplicing in the dry). This is for connections between the power cable and the harness, and between the harness and heating assemblies.

4. Intake Heating Element Assemblies

a. Three intake cone assemblies.

b. Three collar-type heating units at the intake.

c. One collar-type heating unit in Shorewell #3 piping.

5. All heating elements, cables, panels, and appurtentances shall be furnished by one equipment supplier. The equipment supplier shall have responsibility for the complete and proper operation of the heating system and controls as specified and furnished.

6. Cone assemblies shall incorporate magnesium anodes to protect against corrosion.

7. The equipment supplier shall act as the "system integrator" to perform oversight of the heating system installation and integration. The system integrator shall have responsibility for the complete and proper operation of the all heating system components and instrumentation equipment as specified and furnished. The CONTRACTOR shall maintain a representive of the equipment supplier onsite during all heating system installation activities.

8. The CONTRACTOR shall provide the services of the equipment supplier's representative for a minimum of one (1) day to train the OWNER's operating personnel on the heating system operation and maintenance practices.

1.3 SUBMITTALS

A. Provide submittal information pertinent to the heating control system in accordance with the following specifications:

1. Section 26 00 00 – Electrical Work, General.

2. Section 26 01 26 – Electrical Tests.

3. Section 26 05 15 – Industrial Control Panels.

4. Section 26 05 19 – Wire and Cabling.

B. Operation and Maintenance data.

1. Prepare and submit 5 sets of Operation and Maintenance instructions to the ENGINEER, for subsequent use by the OWNER's maintenance personnel.

2. The Operation and Maintenance instructions shall contain a detailed description of the operation of the heating system, with recommendations and instructions for testing and maintaining the system.

3. Provide all passwords needed to allow OWNER full access to heater control programming and operation.

C. Shop Drawings.

1. Power supply schematics.

2. Wiring diagrams.

3. Start-up and testing procedures and reports. This shall include all performance and loop resistance testing to verify the system is operating as intended.

4. Intake cone assemblies dimensional drawings, including connection details and specialty fabrications. Drawings shall incorporate intake cone dimensions in order to verfy compatibility and fit between the heating system elements and intake cones.

5. Collar-type heating units, dimensional drawings and connection details.

6. Data sheets on controls, panels, and sensors.

7. Complete cable data from the manufacter, including installation plan. This shall include type and rating, voltage class, AWG, conductor material, insultation, weight, and the cable manufacturer's recommended tolerances for pulling lengths and handling, Installation plan shall include the CONTRACTOR's methods for storing, protecting, pulling the cable through the intake pipe, and final inspection.

8. Connection coupling details.

9. Loop drawings: Provide all electrical information required in the preparation of loop drawings, including but not limited to; conduit numbers and associated signals contained within each conduit, wire numbers, equipment terminal numbers, junction boxes and signals contained within each junction box, equipment power sources, and associated circuit numbers.

1.4 QUALITY ASSURANCE

A. Experience - The Intake Heating System shall be provided by a supplier having at least 5 years of current and continuous experience designing, manufacturing, and installing similar ice control systems on the Great Lakes. The system supplier shall submit descriptions of and references for at least three similar projects completed within the last 5 years. Projects completed must be currently in operation.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

A. The Intake Heating System is intended to minimize or eliminate the formation of ice on the intake structure inlet cones and within the lateral intake pipes, maintaining free flow of water through the intake during all historically experienced weather conditions at this site. This shall be accomplished by the assembly of electrical resistance heating elements housed in and arranged within heating system subassemblies designed to meet the specific geometry and hydraulic conditions of the proposed 60-inch intake.

B. The System shall be capable of applying suitable amounts of power to the intake heating sub-assemblies and collar-type units as determined by the MANUFACTURER.

C. The System shall be equipped with an automated power control system that will adjust the level of power applied to the heating elements in proportion to the lake water temperature. The System shall maintain a base line level of power regardless of the lake water temperature, to maintain the integrity of the system and to coincidentally provide an inhospitable condition for the attachment and growth of zebra and quagga mussels.

D. The System, consisting of three (3) intake cone subassemblies, three (3) annular subassemblies located in the two branches of the intake structure, and one (1) annular subassembly located in the Shorewell #3 piping shall have a minimum of four independent power supply circuits. A portion of the electrical resistance heating elements within each of the heating subassemblies will be connected to each of the power supply circuits, such that if any one power circuit fails, each heating subassembly shall maintain at least 60 percent of its heating capacity.

E. The System shall include two (2) water temperature sensors supplying the control system with input control signals to adjust the power output.

F. The System shall be equipped with a Programmable Logic Control (PLC) based controller and Human Machine Interface (HMI) screen allowing for operator monitoring and control.

G. The System shall have the capability of transmitting its operating and control functions to the Evanston SCADA system.

H. The System shall have a pair of dry output contacts indicating a general alarm for the heating system activated when any major component of the system fails to perform as called for.

1.6 WARRANTY

A. Provide a 1-year warranty from the heating system supplier to the OWNER. Under terms of warranty, the heating system supplier shall repair or replace, without cost to OWNER, parts of the heating system, which fail during operation under any expected conditions. This excludes damage from vandalism or accidental damage by OWNER.

B. Coordinate repairs or replacements under warranty with OWNER's personnel. Accomplish repairs or replacements within 30 calendar days after notification by OWNER that system is not performing as specified. If repairs within 30 calendar days will interfere unacceptably with OWNER's operation, accomplish repairs at a mutually acceptable later date. Delay shall not relieve heating system supplier of his obligation to make repairs without cost to OWNER.

PART 2 -- PRODUCTS

2.1 HEATING SYSTEM SUB-ASSEMBLIES

A. Heating system sub-assemblies

1. Materials – Heating system sub-assemblies shall be constructed of 304L stainless steel plate with a minimum thickness of 0.25 inches. All seams shall be continuous, full penetration welds.

2. Intake cone sub-assemblies – Three sub-assemblies are required. Each sub-assembly shall be constructed to match the geometry of the intake cone and include anchoring assemblies to maintain contact with the intake cone. The Contractor shall verify measurements of cones and collars prior to fabrication of heating assemblies to ensure proper fit.

   a. Resistance heating elements shall be enclosed in the subassembly configured to provide heat around the circumference of the intake rim and throughout the cone shaped section of the intake. Resistance heating elements shall be supplied with power from three independent circuits and attach to power supply cables via waterproof connectors.

   b. Provide penetrations through the assembly to make final connections from the power supply cables.

   c. Provide mounting brackets for chlorine feed assemblies which are incorporated into cones. See Contract Drawings for locations and mounting requirements.

3. Sub-assemblies shall be complete with integral stiffeners and lifting points to maintain the units' geometry during handling, installation and removal. The design shall minimize the obstructions to the water flow through the assembly.

4. Two (2) annular branch pipe sub-assemblies are required. Each sub-assembly shall be constructed to match the geometry of the intake branch pipes and include anchoring assemblies to maintain their location the branch pipes. Resistance heating elements shall be enclosed in the sub- assembly configured to provide heat around the circumference of the intake branch pipes. Resistance heating elements shall be connected into the three independent circuits and water-proof connections shall penetrate the assembly for connection to the power supply cables.

2.2 CONTROL PANEL

A. All components of the heating system control panel shall be commercially available and manufactured and comply with all NEC,IEEE and UL standards.

B. NEMA Enclosure Rating: 4X 316 Stainless Steel.

1. Captive stainless steel cover screws threaded into sealed wells.

2. Unpainted, brushed finish.

C. Provide disconnecting, short-circuit, and overcurrent protection for all control panels.

D. Provide PLC components, programming, and all associated controls for a fully functional system.

1. Provide 9” touchscreen HMI, with all associated software, programming, and complete functionality to control the process.

2. The control panel shall allow the heaters to be operated in auto or manual mode.

E. The system shall monitor the following variables locally.

1. Power adjustment: 4-20 ma, local analog control.

2. Power output: 4-20 ma.

3. Lake Temperature: 4-20 ma and local indication.

4. Fault status.

F. The System shall make following signals available to monitor and control via remote SCADA

1. Power Supply Output (Analog 0-100%)

2. Manual Override input (Analog 0-100%)

3. Water Temperature used by intake heating control system (Analog 0-100F)

4. Auto / Manual output reference selection (Discrete)

5. Remote ON / OFF (Discrete)

6. Fault Status (Discrete)

G. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.

2.3 POWER CABLES

A. Provide new submersible power cables as follows:

1. Cables are for use with cone heating assemblies and collar-type heating units.

2. Cables shall be of sufficient tensile strength and durability to be pulled into place through the intake pipe and associated terminating structures. Sufficient additional length shall be provided to allow for connections to the control panel and to the heating system sub-assemblies in dry conditions.

3. Sufficient cable length shall be provided to allow for expansion and contraction for the entire installation length due to the expected range of water temperatures (32ºF to 85ºF).

4. Cables shall be continuous and without splices between the Control Panel and the Intake structure unless otherwise noted in the Contract Documents.

B. All cable elements shall be suitable for marine applications.

C. All cables and conductors shall be securely fixed to a surface. Excess cable shall be coiled and securly attached to a surface at multiple points.

D. Maintain physical separation of power and control cables at all parts of the installation.

E. Provide 2 spare conductors with the power cable.

2.4 TEMPERATURE PROBES

A. Provide temperature probes to accurately measure temperatures at the 60” intake as required for heating system input and operations.

B. Provide complete data sheets for all instumention and components.

2.5 MISCELLANEOUS

A. Provide all interconnecting power cables, conduit, connectors, supports, and all other components to make a complete and functional system.

B. All voids in the assemblies housing electrical connections shall be filled with approved di-electric epoxy potting material providing a water-tight encapsulation around connections. All submerged connections shall have at least a 1/2" epoxy cover.

C. All voids in the assemblies housing electrical connections shall be pressure tested to 75 psi prior to filling with potting material.

D. Electrical connections shall be crimped splices and sealed to be water tight.

E. All bolts, fasteners, clamps, cable supports, and other hardware shall be 316 stainless steel.

2.6 MANUFACTURERS, OR APPROVED EQUAL

A. **Hulsinger Electric**

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall coordinate all Work with divers and equipment vendors, and provide assistance as needed to supply a fully functional heating system.

B. Materials and equipment shall be inspected prior to installation. Any defective components shall be repaired or replaced at no additional cost to the OWNER.

C. Installation and handling of the heating system cables shall be in accordance with the cable manufacturer's tolerances.

D. Heating system shall be installed in accordance with drawings submitted by CONTRACTOR, which have been reviewed and returned without exception by the ENGINEER.

E. Any damaged to the intake cones or intake piping during installation of the heating cone elements or cable shall be repaired by the CONTRACTOR at no additional cost to the OWNER.

3.2 FIELD QUALITY CONTROL

A. A representative of the manufacture shall be on site during the installation of the heating system, to witness and approve all system component connections, and to perform commissioning and training services. The CONTRACTOR shall provide a means for the manufacture's representative to access the site, including any installation services or inspections to be performed from marine vessels.

B. Submit test reports to ENGINEER describing tests and test results for each test phase.

END OF SECTION

SECTION 23 00 00 - HEATING, VENTILATING, AND AIR CONDITIONING, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide heating, ventilating, and air conditioning systems and associated equipment complete with supports, mounting frames, ventilators, ductwork, piping, louvers, panels, filters, grilles, electric drive units and controls, mechanical equipment, electrical work, appurtenances, testing, and balancing, as indicated in accordance with the Contract Documents.

B. The equipment shall be installed ready for operation.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes, as referenced herein, are indicated in Section 01 42 19 – Reference Standards.

B. The WORK and materials shall be in full accordance with the latest rules and regulations or publications of the State Fire Marshall, the local mechanical code, the local plumbing code, the local building code, and other local codes.

C. Nothing in the Contract Documents shall be construed to permit WORK in violation of the above codes, rules and regulations.

D. In the absence of applicable codes, the installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings

1. Submit complete shop drawings and certificates, test reports, affidavits of compliance, for all equipment, ductwork and piping systems, in accordance with the requirements in Section 01 33 00 – Contractor Submittals, and as indicated in the individual equipment, piping or ductwork Sections.

2. Construction Drawings

a. The HVAC Drawings define the general layout, configuration, routing, size and the general intent of the design. and are not fabrication drawings.

b. The ductwork dimensions provided on the design drawings represent a free area and they are clear inside dimensions. The contractor shall be responsible to account for the loss of free area due acoustical lining, or any internal obstructions, and oversize the ductwork to provide the same free area as the one shown on the design drawings.

c. It shall be the CONTRACTOR's responsibility to develop the Shop Drawings required for the construction of the HVAC system.

3. The Shop Drawings shall include all necessary dimensions and details regarding equipment, pipe and ductwork joints, fittings, valves, appurtenances, design calculations, and material lists.

4. The submittals shall include detailed layout, spool, or fabrication drawings which shall show all fittings, and supports as necessary to accommodate the equipment as a complete and functional system.

B. Equipment Numbers

1. Equipment is identified by assigned numbers for reference and location purposes in the Contract Documents.

2. Indicate the appropriate equipment numbers on the Shop Drawings and other submittals.

C. Furnish certified fan curves for each fan.

1.4 WARRANTY

A. Air conditioners, heaters, fans, ventilators, grilles, and the like, that are provided by the CONTRACTOR shall carry the manufacturer’s standard warranty.

B. Warranties shall be furnished to the ENGINEER upon final acceptance of the completed systems by the OWNER.

C. Refrigerant compressors shall carry a manufacturer's 5-year warranty.

D. Control System

1. The temperature and equipment control system shall be warranted free from defects in workmanship and material under normal use and service for a period of one year after acceptance by the ENGINEER.

2. Equipment that proves to be defective in workmanship or material during the warranty period shall be adjusted, repaired, or replaced by the automatic control manufacturer as part of the Contract.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Quality

1. Mechanisms and other parts shall be amply proportioned for the stresses which may occur during operation and for any other stresses which may occur during fabrication and erection.

2. Individual parts furnished which are alike in all units shall be alike in workmanship, design, and materials, and shall be of the manufacturer's top-line, industrial-commercial grade.

B. Supports

1. Equipment and appurtenances shall be firmly anchored or connected to supporting members.

2. Equipment shall be supported on restrained spring-type vibration isolators.

3. Supports as required for the proper installation of the equipment, but not forming an integral part of the building structure, shall be provided unless otherwise indicated.

C. Noise and Vibration Control

1. The system shall be free of objectionable vibrations and noise.

2. Provide flexible connections in ducts and piping connections to fans, compressors, and other vibrating equipment.

D. Seismic Restraints

1. Design the equipment, duct and piping supports and restraints for static, dynamic, and seismic loads in Zone 4 in accordance with the International Building Code.

2. Seismic restraints shall not induce stresses in the equipment, ductwork and piping caused by thermal expansion and contraction.

3. Comply with spec 01 33 17 – Seismic and Wind Design Criteria

2.2 MOTORS

A. Motors provided with the equipment shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.

B. Motors shall be in conformance with the requirements of Section 26 05 10 – Electric Motors.

C. Each motor shall bear the manufacturer's nameplate with complete motor data.

D. Each motor shall be of ample size and construction to continuously carry the loads which might be imposed by the equipment throughout the full range of operation of the equipment.

E. The maximum motor loading shall be less than or equal to the nameplate horsepower rating, exclusive of the service factor.

2.3 ELECTRICAL WORK

A. The WORK of this section shall include:

1. Provide controls, sensors and control panels relating to the HVAC systems, including starters, thermostats, motorized dampers, louver operators and other equipment as indicated.

2. Provide control wiring of 120-volt and less as indicated in this Section and in conformance the requirements of Division 26 – Electrical and Division 40 – Instrumentation and Control.

B. The WORK of Division 26 shall include:

1. Provide local power disconnects, where required.

2. Provide circuit breakers, starters in motor control centers, and 120-, 208-, 240- and 480-volt power feeders from the starters and circuit breakers to the HVAC equipment, as indicated.

C. Starters, whether as an integral or separate part of the equipment, shall be in accordance with the requirements of Section 26 05 15 –Industrial Control Panels and Miscellaneous Electrical Devices.

D. Enclosures shall be of the same NEMA class as the electrical equipment in the same area.

E. Starters shall be of the same manufacturer as the starters indicated under Section 26 05 15 –Industrial Control Panels and Miscellaneous Electrical Devices.

F. Low-voltage control wiring shall be in accordance with the National Electric Code.

G. Control wiring for line voltage 120-volt and higher shall be in conformance with the requirements of Section 26 05 19 – Wires and Cables.

H. Control Panels shall be in conformance with the requirements of Section 26 05 15 – Industrial Control Panels and Miscellaneous Electrical Devices.

I. Conduit shall be in conformance with the requirements of Section 26 05 33 – Electrical Raceway Systems and Section 26 05 43 – Underground Raceway Systems.

2.4 PIPING AND DUCTWORK INSULATION

A. HVAC Pipe Insulation shall be in conformance with the requirements of Section 23 07 19 – HVAC Pipe Insulation.

B. HVAC Ductwork insulation shall be in conformance with the requirements of Section 23 07 13 – HVAC Ductwork Insulation.

2.5 WELDING

A. The welding of black steel or alloy pipe shall be carried out in strict accordance with AWS procedures and the codes and ordinance of the City of Evanston and the State of Illinois pertaining to welded steel pipelines.

B. Welding shall be accomplished by means of the shielded electric arc process and performed by workers who are certified for this WORK.

2.6 HANGERS AND SUPPORTS

A. Anchorage and bracing for all suspended ductwork and other distribution systems needs to be provided per 2016 CBC Section 1613/ASCE 7-10 Chapter 13

B. Provide all necessary hangers, supports, concrete inserts, anchors and guides for material and equipment to be installed.

C. No perforated strap hangers and no wire supports will be accepted.

D. Insulation Allowance

1. Hangers supporting insulated ducts shall be sized to fit the pipe plus the insulation.

2. The insulation at support points shall be provided with a metal shield in order to prevent damage to the insulation.

E. Anchors and guides shall be constructed of stainless steel, in accordance with approved Shop Drawings, and as indicated.

F. Anchors

1. Anchorages shall be obtained by welding lugs onto the pipe and providing abutting surfaces against the lugs to restrict longitudinal movement.

2. Anchors shall be designed such that the pipe may be removed by removing bolts; no welding of pipe to the anchor will be accepted.

3. Bolting materials shall be cadmium-plated.

G. Guides shall be located not more than 20 feet from each expansion loop or joint.

H. Hangers for ductwork and equipment shall be as indicated and in accordance with the guidelines of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

I. Inserts shall be galvanized.

2.7 TEMPERATURE AND EQUIPMENT CONTROL

A. General

1. Design and provide a complete electric-electronic system of automatic temperature control as indicated.

2. The temperature control equipment and devices shall be furnished by **Johnson Controls**, **Honeywell**, or **Barber Colman**.

B. Wiring and Switches

1. Provide wiring incidental to the temperature control system, including electrical interlock.

2. Furnish detailed wiring diagrams along with necessary supervision.

3. Provide control wiring (line voltage or low voltage) as required to complete the temperature control system (by interconnecting starters, thermostats, PE switches, relays, and like devices) in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

4. Provide HOA switches in accordance with the requirements of Section 26 05 15 – Industrial Control Panels and Miscellaneous Electrical Devices.

5. Switches shall be UL-listed and of a type to meet the current and voltage requirements of the particular application.

C. Temperature Sensor / Thermostats

1. Room temperature sensor / Thermostat shall be PECO Model TF115-001 SPDT

2. Temperature Control Range: 40º F to 110º F (4º C to 43º C)

3. Differential: 3º F (1.7º C)

4. Maximum Ambient Temperature: 140º F (60º C)

5. Raintight NEMA 4X enclosure

6. Provide an insulating back where exterior wall mounting is indicated.

D. Relays

1. Provide 2-position relays, capacity relays, sequencing relays, and other controls as necessary in order to provide a properly operating automatic control system.

2. Relays shall be UL-Listed and of a type to meet the current and voltage requirements of the particular application.

E. Control Panels

1. General

a. Control panels shall be provided with relays, control switches, transformers, pilot lights, timers, time clocks, step controllers, gages, thermostats (unless otherwise indicated), and other accessories necessary for the particular system.

b. The panels shall be of aluminum construction with a baked enamel finish, and shall be provided with a hinged front door and locking handle.

c. Manual switches and direct-reading gauges shall be flush-mounted on the front face, and identified by engraved and riveted **Bakelite** or laminated plastic nameplates with white letters on black background.

d. Manual switches shall be of heavy-duty, oil-tight construction.

2. Wiring

a. Control devices shall be prewired internally.

b. Wires leaving the panel shall be terminated at separate numbered terminal strips.

c. Provide individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.

d. Power and control circuit requirements shall be as indicated on the Electrical Drawings.

e. Identify wires by color coding or numerical tags at both ends.

f. Wire each control device to the terminal strip without splices.

g. Provide integral circuit protection for panel-mounted control devices.

h. Wire each panel with a single 20-amp, 120-volt, ac feeder in accordance with the requirements of Section 26 05 15 – Local Control Panels and Miscellaneous Electrical Devices.

3. Diagrams

a. Secure the panel electrical wiring diagrams to the inside of the panel door.

2.8 ALUMINUM DUCTWORK

A. General

1. Provide air-tight and well-braced ductwork.

2. Carefully support the ductwork in horizontal runs, with rod and angle supports at no greater than 8-foot intervals.

3. Run ductwork as close as possible to the indicated layouts.

B. Construction

1. Construct sheet metal ducts and plenums with air-tight joints and seams in accordance with ASHRAE standards and the SMACNA Duct Construction Manual.

2. Tape the joints on concealed ducts with pressure-less tape and adhesive, except for welded and soldered joints.

3. Ductwork materials shall be aluminum, unless otherwise indicated.

4. Provide the following duct gauges, as a minimum:

Maximum Dimension of Duct (inches)	Aluminum B and S Gauge
12 and less	24
13 through 30	22
31 through 54	20
55 through 84	18

5. All low pressure ductwork shall be designed for 3 inches vacuum and pressure and be constructed of sheet metal of not less than the gauge designated in table above, and gauge designations provided by Brown and Sharpe Standards.

6. Radius of bends shall be not less than 1.5 duct diameters, unless otherwise indicated.

7. Except where accepted by the ENGINEER, provide fan discharge connections and ductwork reductions with duct side slopes not exceeding 30 degrees.

8. Properly insulate aluminum duct and supports from concrete or dissimilar metals by an applied bituminous coating or by rubber gaskets at contact points.

9. Construct the units in accordance with the ASHRAE guide recommendations for high-pressure ductwork.

10. Seams shall be lock-formed and mastic-filled.

C. Seams

1. Provide double-locked seams.

2. Provide reinforcements at intervals not greater than 30 inches along the duct.

3. No "S" seams will be accepted.

D. Low-Pressure Ductwork

1. Design all low-pressure ductwork for 3 inches vacuum and pressure.

2. Gauge designations refer to Brown and Sharpe Standards.

E. Flexible Connections

1. Attach the equipment to the ducts through using flexible connections in order to facilitate removal of the units and for sound isolation.

2. Provide flexible connectors consisting of heavy duct canvas or woven glass fabric, silicon-coated.

3. Canvas connectors shall be composed of a heavy cotton that is impregnated for waterproofing and fire retardance.

4. Use glass fabric where temperatures exceed 200 degrees F.

5. The weight of the canvas shall be 20 ounces per sq yd.

6. The weight of the glass fabric shall be approximately 12 ounces per sq yd.

7. Flexible duct shall be insulated.

8. The maximum length of flexible duct shall not exceed 10 feet.

9. Flexible duct connections shall be composed of banded or flanged 8-oz canvas, reinforced plastic, or equal, at each point where a blower unit is connected to a duct.

10. Maintain a minimum clearance of 3 inches between the duct and the source of vibration.

11. Provide materials that join and support the flexible duct in accordance with the latest edition of SMACNA.

F. Supports

1. Provide aluminum angles with 304 stainless steel threaded hanger rods as supports for horizontal ducts and plenums.

2. Supports for vertical ducts shall be aluminum of the angle bracket type.

3. Sufficiently brace inlet ducts to withstand the maximum negative pressure.

2.9 PAINTING

A. Painting of the equipment and materials shall comply with the requirements of Section 09 96 00 – Protective Coating.

B. Touch-Ups

1. Touch up factory-painted surfaces that are rusted or scratched.

2. Clean finishes to be touched up to bright metal, prime with a corrosion inhibitor, and finish with a coating to match the original finish.

PART 3 -- EXECUTION

3.1 GENERAL

A. Openings - New Construction

1. Provide necessary openings in walls, floors and roofs for the passage of heating and ventilating equipment in the buildings.

2. Openings shall be as indicated or as required to provide passage for heating and ventilating WORK.

3. Provide hanger and support inserts into masonry or structural steel as required for proper completion of the WORK.

B. Openings - Existing Construction

1. Provide openings required in the existing construction for piping and equipment that are not specifically indicated.

2. Openings shall be cut in a neat and orderly manner with as little damage to existing structures as possible.

3. The patching of openings that have been cut shall match the existing construction.

4. Provide hangers and supporting members installed in the existing masonry or structural steel as required for proper completion of the WORK.

3.2 BALANCING AND TESTING

A. Balancing Subcontractor

1. After the installation WORK has been completed, the CONTRACTOR shall provide the services of an independent balancing subcontractor who shall perform necessary adjustments of exhaust fans and heating units.

2. The balancing subcontractor shall:

a. Have at least 5 years of balancing experience, and experience in at least 5 projects of the Project type;

b. Not be associated with any firms doing engineering or construction work in HVAC and/or Plumbing;

c. Use the balancing methods approved by the Associated Air Balance Council; and,

d. Send a copy of all correspondence and reports, as they are written, pertaining to this project, directly to the ENGINEER.

B. The CONTRACTOR shall:

1. Provide labor, tools, testing equipment and appliances for the necessary testing and adjustment that is required;

2. Submit to the ENGINEER an experience resume and project resume for approval of the balancing subcontractor;

3. Demonstrate to the OWNER, in an extensive operating test covering every component of the installation, that the entire heating, ventilating and air conditioning system meets the indicated requirements and is ready for continuous, satisfactory operation; and,

4. Make repairs and revisions as necessary to make the system operative, as part of the Contract.

END OF SECTION

SECTION 23 15 60 – ELECTRIC HEATING EQUIPMENT

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide the electric heaters, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. Where 2 or more heaters or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be furnished in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.3 QUALITY

A. Codes and Permits

1. The WORK shall be in strict accordance with the State Mechanical Code, the State of Illinois, City of Evanston, and any other authorities having jurisdiction.

2. The CONTRACTOR shall have the required certification and be thoroughly familiar with the local codes.

3. The CONTRACTOR shall obtain and pay for necessary permits.

B. Diligent Care

1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up, erection of piping and placing of equipment.

2. The CONTRACTOR shall remove all stains and repair all damage before final acceptance of the WORK.

C. Materials

1. The materials used in connection with the electric heating system work shall:

a. Be new;

b. Be free from flaws and defects;

c. Be fully equal to the quality specified; and,

d. Conform to the requirements of applicable specifications and standards.

2. If during the construction of the Project the ENGINEER finds materials that have identifying marks removed, or lacking such marks completely, such items may be rejected until the CONTRACTOR has shown proof that said items conform to the

indicated requirements, where the adequacy and extent of such proof shall be determined by the ENGINEER.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Motors shall be in conformance with the requirements of Section 26 05 10 – Electric Motors.

B. The electrical system and components for electric heating systems shall be in conformance with the requirements of Section 23 00 00 – Heating, Ventilating, and Air Conditioning, General.

2.2 CORROSION-RESISTANT ELECTRIC UNIT HEATERS

A. General

1. Provide corrosion-resistant electric unit heaters as indicated.

2. The heaters shall be provided with built-in controls.

3. The heaters shall be UL-listed and CSA-certified for corrosive areas and NEMA 4X hose-down requirements.

4. The heaters shall be of the forced fan type, and of the power and voltage ratings as suitable for the electrical distribution system as indicated.

B. Construction

1. The heating elements shall be of finned tubular construction and composed of Type 316 stainless steel.

2. Provide stainless steel fittings to form a watertight seal between the elements and the junction box.

C. Motors

1. Motors shall be:

a. UL-listed;

b. CSA-certified;

c. Totally enclosed;

d. Epoxy painted; and,

e. Provided with permanently lubricated ball bearings

2. Motors shall be designed to resist moisture and corrosion, shall be fitted with an epoxy-coated aluminum fan blade, and shall be factory-wired to a NEMA 4X enclosure.

D. Shroud

1. The heating elements and motor shall be enclosed within a sturdy, heavy-gauge, stainless steel shroud.

2. The shroud shall be provided with a louvered outlet grille and a rear grille, each painted with one coat of zinc chromate primer and 2 coats of corrosion-resistant epoxy painting.

E. Electrical

1. Provide a NEMA 4X enclosure to house element terminals and the following standard built-in controls:

   a. Over-temperature cutout with automatic reset;

   b. Fan delay relay;

   c. Required contactors; and

   d. Terminal blocks for field wiring.

2. Provide a separate motor contactor along with a 120V control transformer.

F. Provide a universal mounting bracket constructed of 14-gauge stainless steel, and suitable for ceiling or wall mounting.

G. The following optional controls shall be built-in and factory-prewired in the NEMA 4X enclosure:

1. Thermostat with external adjustable knob;

2. Selector switch, 3-position;

3. Pilot light to indicate when heating elements are energized;

4. Secondary manual reset thermal cutout;

5. Anodized aluminum or epoxy-painted steel case material; and,

6. Power disconnect switch.

H. Accessory Thermostat

1. Provide an accessory thermostat with each heater for remote wall mounting.

2. The thermostat shall be UL-listed and provided with a NEMA 4X enclosure.

I. Corrosion-Resistant Electric Unit Heaters Manufacturer, or Equal:

1. **Chromalox, HD3D series**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The electric heating equipment shall be installed by a qualified installer in strict accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 23 34 00 – FAN EQUIPMENT

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide fans, blowers, ventilators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. Where 2 or more fans, blowers, ventilators or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Submit certified fan curves for each fan

C. O&M Data

1. Submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.3 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

1. Drive Belts: Provide one for each fan

1.4 REFERENCES

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

1. Air Moving and Conditioning Association (AMCA):

a. AMCA 300-14 Reverberant Room Method for Sound Testing of Fans

b. Standard 99, Standards Handbook, Reverberant Room Method for Sound Testing of Fans.

c. Standard 210, Laboratory Methods of Testing Fans for Rating.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

a. HVAC Applications chapter in “Seismic Restraint Design”.

b. Spec 01 33 17 – Seismic and Wind Design Criteria

3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.

4. National Electrical Manufacturers Association (NEMA): MG 1-12.53a, Motors and Generators.

5. National Fire Protection Association (NFPA):

   a. 70, National Electric Code (NEC).

   b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

6. Occupational Safety and Health Act (OSHA).

7. Underwriters Laboratories Inc. (UL): Product Directories.

1.5 MOTORS

A. All motors shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.

B. Motors shall be in accordance with the requirements of Section 26 05 10 – Electric Motors.

C. Each motor shall bear the manufacturer's nameplate with complete motor data.

D. Each motor shall be of ample size and construction to carry continuously all loads which might be imposed by the piece of equipment it drives throughout the full range of operation of the equipment, and the maximum motor loading shall in all cases be less than or equal to the nameplate horsepower rating, exclusive of the service factor.

E. All 2-speed motors shall be 2-winding motors.

PART 2 -- PRODUCTS

2.1 DIRECT DRIVE AXIAL INLINE EXHAUST FANS

A. FAN HOUSING AND OUTLET

1. Fan housing to be aerodynamically designed with integral punched flanges for sizes up through size 160 (63 inch diameter).

2. Fan housing shall be constructed of rolled steel with a continuous seam weld.

3. Housing to be coated with a minimum of 3 mils Hi-Pro Polyester, an electrostatically applied and baked high performance polyester urethane. Finish color shall be gray. Coating must exceed 1,000-hour salt spray under ASTM B117 test method.

4. Motor support framework to be constructed of structural steel that is suitable to handle the weights of the motor and propeller. Motor supports within the fan housing to be welded to the fan casing. Bolted construction is not acceptable. All support framework to be coated with a minimum of 3 mils of Hi-Pro Polyester, an electrostatically applied and baked high performance polyester urethane. Finish color shall be gray. Coating must exceed 1,000-hour salt spray under ASTM B117 test method.

B. FAN IMPELLER

1. A taper lock bushing shall be used to mount the propeller to the motor shaft.

2. Fan propeller shall use cast aluminum airfoil blades. Blades to be adjustable within a cast aluminum hub to allow for performance changes. The propeller shall be both statically and dynamically balanced.

3. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

C. FAN MOTORS AND DRIVE.

1. Motors shall be 3600 RPM, 1800 RPM, 1200 RPM, 900 RPM (nominal - 60 Hz), 3000, 1500, 1000, 800 (nominal - 50 Hz), TEFC enclosure with a 1.15 service factor.

2. Motors must be standard NEMA T-Frame designs that are readily available from motor vendors. Suppliers using C-Face or Pad Mount motors must include provisions to provide replacement motors in case of a motor failure due to long motor lead times.

3. Motors for emergency smoke ventilation shall use insulation class F or H as noted below:

a. 302 °F (150 °C) for a minimum of 5 hours of operation requires class F insulation.

D. GRAVITY BACKDRAFT DAMPER

1. Provide round backdraft damper to be horizontally mounted on the duct.

2. Damper shall be gravity operated.

3. Damper frame, blades and axle shall be 304 or 316 stainless steel or 20 ga galvanized steel at minimum for corrosion resistance.

4. Damper shall have a

a. minimum velocity rating of 2000 fpm,

b. minimum differential pressure rating of 3 in.wg

c. temperature rating of 180F

d. leakage rating of 4 cfm/sq ft at 1 in wg.

5. Damper Manufacturer, or Equal

a. Greenheck, Model WDR

E. Fan Manufacturer, or Equal

1. **Greenheck, Model AX**

2. **Cook**

3. **TwinCity**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Fans, blowers, ventilators, and hoods shall be installed in strict accordance with the manufacturer's recommendations.

B. Pipe the housing drains to the nearest utility drain.

END OF SECTION

SECTION 26 00 00 – ELECTRICAL WORK, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide the electrical WORK, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all Sections in Division 26, except as otherwise indicated.

C. The WORK of this Section is required for operation of electrically-driven equipment provided under Specifications in other Divisions.

D. The CONTRACTOR'S attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment Specifications, the WORK of instrumentation Sections, and the WORK of Section 26 05 10 – Electric Motors.

E. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various Sections of Division 26 is included as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.

F. Equipment supports and foundations shall be in conformance with the requirements of Section 46 01 00 – Equipment General Provisions.

1.2 REFERENCE STANDARDS

NEC (NFPA 70)	National Electrical Code: Evanston has adopted the 2011 NEC with Evanston amendments.
NETA	International Electrical Testing Association
NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)

A. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

B. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.

C. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.3 SIGNAGE AND MARKINGS

A. Identification

1. Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal, state, OSHA, and NEC requirements.

B. Local Disconnect Switches

1. Legibly mark each local disconnect switch for motors and equipment in order to indicate its purpose, unless the purpose is indicated by the location and arrangement.

C. Warning Signs

1. 600 Volts Nominal, or Less

a. Mark entrances to rooms and other guarded locations that contain live parts with conspicuous signs prohibiting unqualified persons from entering.

2. Greater than 600 Volts

a. Buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at greater than 600 volts nominal shall be lockable.

b. Provide permanent and conspicuous warning signs reading as follows: DANGER – HIGH VOLTAGE – KEEP OUT.

3. Mark indoor electrical installations that are open to unqualified persons and contain metal-enclosed switchgear, unit substations, transformers, and other similar associated equipment over 600 volts nominal, with appropriate caution signs.

4. Outside Branch Circuits and Feeders over 600 Volts

a. Post warning signs in plain view where unauthorized persons might come in contact with live parts: WARNING – HIGH VOLTAGE – KEEP OUT.

D. Isolating Switches

1. Provide isolating switches not interlocked with an approved circuit-interrupting device with a sign warning against opening them under load.

1.4 PERMITS AND INSPECTION

A. Obtain permits and pay inspection fees according to the General Conditions.

1.5 CONTRACTOR SUBMITTALS

A. General

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

2. Custom-prepare Shop Drawings.

3. Drawings or data indicating "optional" or "as required" equipment will not be accepted.

4. Cross out options not proposed or delete from the Shop Drawings.

B. Shop Drawings: Include the following:

1. complete material lists stating manufacturer and brand name of each item or class of material.

2. Shop Drawings for grounding WORK not specifically indicated

3. front, side, rear elevations, and top views with dimensional data

4. location of conduit entrances and access plates

5. component data

6. connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers

7. method of anchoring, seismic requirements, weight

8. types of materials and finish

9. nameplates

10. temperature limitations, as applicable

11. voltage requirement, phase, and current, as applicable

12. front and rear access requirements

13. test reports

14. grounding requirements

C. Catalog Cuts

1. Submit catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material.

2. Stamp the catalog data sheets in order to indicate the Project name, applicable Specifications Section and Paragraph, model number, and options.

D. Materials and Equipment Schedules

1. Within 30 Days of the commencement date in the Notice to Proceed, deliver to the ENGINEER a complete list of materials, equipment, apparatus, and fixtures that are proposed for use.

2. Include in the list the type, size, name of manufacturers, catalog number, and such other information as required to identify the item.

E. Technical Manuals

1. Submit complete information in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

2. As-Built Drawings

a. Prepare as-built drawings, showing invert and top elevations and routing of duct banks and concealed below-grade electrical installations.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

1.6 AREA DESIGNATIONS

A. General

1. Designations for raceway system enclosures shall comply with the requirements of Section 26 05 33 – Electrical Raceway Systems.

2. Designations for electrical WORK specifically indicated in other Sections shall comply with the requirements of those Sections unless indicated otherwise.

3. Designations for other electrical WORK not included in the above Paragraphs shall be as follows:

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	3R	7	9	12	Notes
Battery Room - Transformer only	X					NEMA 2 is an acceptable alternative

4. Designations for electrical WORK not included in the above Paragraphs shall be NEMA 4X.

B. Material Requirements

1. Construct NEMA 4X enclosures of Type 304 or 316 stainless steel, except in chlorine areas where non-metallic enclosures shall be provided.

2. Do not coat NEMA 4X enclosures.

3. Do not coat NEMA 7 and 9 enclosures.

4. Construct NEMA 1, 3R, and 12 enclosures of steel, and prime and coat with ANSI 61 light grey paint.

1.7 TESTS

A. The CONTRACTOR shall be responsible for factory and field tests indicated in Division 26, as required by the ENGINEER, and as required by other authorities having jurisdiction.

B. Furnish necessary testing equipment.

C. Pay the costs of the tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of a faulty installation.

D. Reporting

1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.

2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.

3. Submit field test reports for review prior to Substantial Completion.

E. Remove and replace equipment or material that fails a test, or, if the ENGINEER approves, repair and retested for compliance.

F. Corrections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

1.8 CONSTRUCTION SEQUENCING

A. General

1. Because the continuance of plant operation during the expansion process is critical, the CONTRACTOR shall carefully examine the WORK to be provided in, on, or adjacent to existing equipment.

2. Schedule the WORK, subject to OWNER's approval, to minimize required shutdown time.

3. Submit a written sequencing request, including the sequence and duration of activities to be performed during plant shutdown.

4. Switching, safety tagging, and the like, as required for plant shutdown or to isolate existing equipment, shall be performed by the CONTRACTOR.

5. In no case shall the CONTRACTOR begin any WORK in, on, or adjacent to existing equipment without written authorization from the ENGINEER.

B. Modifications

1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.

2. Perform modifications to existing equipment, panels, and cabinets in a professional manner.

3. Repair coatings to match existing.

4. The costs for modifications to existing electrical facilities that are required for a complete and operating system shall be included as part of the WORK.

C. Existing Utilities

1. Exercise extreme caution when digging trenches to not damage existing underground utilities.

2. The cost of repairs of damages caused during construction shall be included as a part of the WORK.

D. Field Verifications

1. Visit the Site before submitting a Bid to become better acquainted with the WORK of this Contract.

2. The lack of knowledge will not be accepted as justification for extra compensation to perform the WORK.

3. The CONTRACTOR shall be responsible for identifying available existing circuit breakers in lighting panels for the intended use as required.

4. The CONTRACTOR shall be responsible for field verifying the available space in substation switchboards to integrate new power circuit breakers.

5. The cost for the above verifications shall be included as part of the WORK.

E. Installation of Temporary Equipment

1. To facilitate the continuous operation of existing equipment, provide the temporary equipment as indicated.

2. Submit installation and connection details for review and acceptance by the ENGINEER.

3. Costs associated with these temporary installations shall be included as part of the WORK.

4. Temporary wiring and equipment shall remain the property of the CONTRACTOR unless indicated otherwise.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide equipment and materials that are new and are the products of experienced and reputable manufacturers in the industry.

B. Provide equipment and materials listed by UL and bearing the UL label, where UL requirements apply.

C. Provide similar items in the WORK as products of the same manufacturer.

D. Provide equipment and materials of industrial grade standard of construction.

E. Where a NEMA enclosure type is indicated in a non-hazardous location, use that type of enclosure despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.

F. On devices indicated to display dates, display the year as 4 digits.

G. Temperature Ratings of Equipment Terminations

1. Provide terminations and lugs rated for use with 75-degree C conductors.

2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.2 MOUNTING HARDWARE

A. Miscellaneous Hardware

1. Provide nuts, bolts, and washers constructed of stainless steel.

2. Provide threaded rods for trapeze supports constructed from continuous threaded stainless steel, 3/8-inch diameter minimum.

3. Struts

a. Construct struts for mounting of conduits and equipment of stainless steel.

b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.

c. Strut Manufacturer, or Equal: **Unistrut**; **B-Line**

4. End Caps

a. Provide plastic protective end caps for all exposed strut ends

b. End Caps Manufacturer, or Equal: **Unistrut, Model P2860**

5. Anchors

a. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors, and ceilings.

b. Wood plugs will not be accepted.

c. Anchor Manufacturer, or Equal: **"Power-Bolt"** or **"Power-Stud"** as manufactured by **Power Fasteners, Inc.**; similar by **Star**.

2.3 ELECTRICAL IDENTIFICATION

A. Nameplates

1. Fabricate nameplates from white-letter, black-face laminated plastic engraving stock, such as **Formica Type ES-1** or equal.

2. Securely fasten each nameplate, using fasteners constructed of brass, cadmium-plated steel, or stainless steel, and screwed into inserts or tapped holes as required.

3. Provide engraved characters of the block style, with no characters smaller than 1/8 inch top to bottom.

B. Conductor and Equipment Identification

1. Provide imprinted plastic-coated cloth marking devices, such as manufactured by Brady, Thomas & Betts, or equal.

2. Alternatively, provide heat-shrunk plastic tubing, imprinted split-sleeve markers cemented in place.

PART 3 -- EXECUTION

3.1 GENERAL

A. Incidentals

1. Provide materials and incidentals required for a complete and operable system, even if not required explicitly by the Contract Documents.

2. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

B. Field Control of Location and Arrangement

1. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items.

2. Exact locations shall be determined by the CONTRACTOR in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions.

3. Follow the locations on the Drawings, however, as closely as possible.

4. Conduits

a. Where conduit development drawings or "home runs" are indicated, route the conduits in accordance with those requirements.

b. Provide exposed routings as indicated.

c. Size conduits encased in a slab for conduit OD not to exceed 1/3 of the slab thickness, and lay out and space as to not impede concrete flow.

5. Placement

a. Install conduit and equipment in such a manner as to avoid obstructions, to preserve headroom, and to keep openings and passageways clear.

b. Locate luminaires, switches, convenience outlets, and similar items within finished rooms as indicated.

c. Where exact locations are not indicated, such locations will be determined by the ENGINEER.

d. If equipment is installed without instruction and must be moved, the cost of moving shall be included as part of the WORK.

e. Slightly adjust luminaire locations in order to avoid obstructions and to minimize shadows.

6. Circuits

    a. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR'S responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.

    b. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).

    c. Where circuits are combined in the same raceway, derate conductor ampacities in accordance with NEC requirements.

7. Workmanship

    a. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer, and using workers skilled in the WORK.

    b. Coordinate installation in the field with other trades in order to avoid interferences.

8. Protection of Equipment and Materials

    a. Fully protect materials and equipment against damage from any cause.

    b. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.

    c. Keep moving parts clean and dry.

    d. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.

C. Provide power wiring in conduit for the HVAC equipment in accordance with the requirements of Section 23 00 00 – Heating, Ventilating, and Air Conditioning.

D. Provided starters shall be in accordance with the requirements of Section 26 05 15 – Industrial Control Panels and Miscellaneous Electrical Devices for starters not in MCC'S.

E. Provide control wiring operating at 120 volts and less as indicated in Section 23 00 00 – Heating, Ventilating and Air Conditioning. HVAC temperature control wiring shall be provided as part of the Division 23 scope of work.

3.2 CORE DRILLING

A. Perform core drilling as required for the installation of raceways through concrete walls and floors.

B. Base the locations of floor penetrations, as may be required, on field conditions.

C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.

D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities.

E. Repair damage to encased conduits, wiring, and piping as part of the WORK.

3.3 EQUIPMENT ANCHORING

A. Floor-supported, wall, or ceiling-hung equipment and raceways shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located. Refer to Section 01 33 17 – Structural Design, Support and Anchorage for support and anchorage requirements.

B. Provide wall-mounted panels that weigh more than 500 pounds or that are within 18 inches of the floor with fabricated steel support pedestals.

C. If the supported equipment is a panel or cabinet enclosed within removable side plates, match supported equipment in physical appearance and dimensions.

D. Provide transformers hung from 4-inch stud walls and weighing more than 300 pounds with auxiliary floor supports.

E. Provide leveling channels anchored to the concrete pad for MCC's, switchgear and other electrical equipment mounted on housekeeping pads.

F. Manufacturer's Recommendations

1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract.

2. Submit such recommendations as Shop Drawings as indicated.

3.4 EQUIPMENT IDENTIFICATION

A. Provide nameplates for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations.

B. In addition to nameplates, equip control devices with standard collar-type legend plates.

C. Identify control devices within enclosures as indicated and similar to the subparagraph above.

D. Provide suitable inscribed finish plates for toggle switches that control loads out of sight of switches and for multi-switch locations of more than 2 switches.

E. Use equipment names and tag numbers, where indicated, on nameplates.

F. Provide typewritten circuit directories for panelboards, that accurately reflect the outlets connected to each circuit.

G. Terminal Blocks

1. Label termination points on terminal blocks by identifiers on the blocks.

2. Provide identifiers that have been preprinted by the terminal manufacturer or custom-printed.

3. Hand-lettered markers will not be accepted.

H. Provide arc-flash labels for all distribution equipment, stand-alone disconnects, starters, and VFDs. Fill in all values as required by NFPA 70E, and as calculated as part of the Protective Device Study. Verify that all settings as prescribed by the approved Protective Device Study have been implemented in the field.

3.5 CLEANING

A. Before final acceptance, thoroughly clean the electrical WORK of cement, plaster, and other materials.

B. Remove temporary tags, markings, stickers, and the like.

C. Remove oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.

D. Apply touch-up paint to scratches on panels and cabinets.

E. Vacuum clean electrical cabinets and enclosures. Do not use compressed air to clean cabinets.

F. Clean luminaires inside and out. Replace failed lamps.

G. Properly dispose cleaning debris and refuse off-site.

END OF SECTION

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SECTION 26 01 26 – ELECTRICAL TESTS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 40. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. The requirements of Section 26 00 00 - Electrical Work, General, apply to the WORK of this Section.

D. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable NETA Acceptance Testing Specifications, NEMA, ANSI, NFPA, and ASTM Standards.

1.2 REFERENCES

A. General

1. The publications listed below form a part of this specification to the extent referenced.

2. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

B. American National Standards Institute (ANSI)

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

D. IEEE 400-2001, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

E. IEEE 576-2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications

F. InterNational Electrical Testing Association (NETA)

G. NFPA 70, National Electrical Code (NEC)

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 00, Contractor Submittals.

B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:

1. Detailed procedures in sufficient detail to verify conformance with these Specifications.

2. Incorporation of the Test Record Sheets included at the end of this Section.

3. Detailed comprehensive testing schedule including:

a. Each major piece of electrical distribution equipment.

b. Each major electrical subsystem.

c. Duration of each test.

d. Milestone test completion date.

e. Ambient Conditions at time of test

f. Date of test results submittals following completion of the tests.

g. Names and qualifications of the individual(s) responsible for performing the testing.

C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the “as-left” settings of all devices, relays, circuit breakers, etc.

D. Test result shall be submitted in one submittal

E. Test reports shall be based on NETA’s latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA’s Acceptance Testing Specifications latest edition.

1.4 COMMISSIONING

A. Commissioning during the 7 Day test in Section 01 75 00 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.

PART 2 -- TESTING & REPORTS

2.1 PRE-ENERGIZATION AND OPERATING TESTS

A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.

2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.

4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.

5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.

6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS-2021, *For Electrical Power Equipment and Systems*, published by the InterNational Electrical Testing Association.

2.2 TEST REQUIREMENTS

A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.

1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.

2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

a. Visual and Mechanical Inspection

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Verify tightness of electrical connections.

4) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.

5) Verify freedom of movement, end play, and alignment of rotating disk(s).

b. Electrical Tests

1) Verify accuracy of meters at all cardinal points.

2) Calibrate watthour meters according to manufacturer's published data.

3) Verify all instrument multipliers.

4) Verify that current transformer and voltage transformer secondary circuits are intact.

3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.

4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

5. Low Voltage Cables-600 volts Maximum

a. Visual and Mechanical Inspection

1) Compare cable data with drawings and specifications.

2) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.

3) Inspect bolted electrical connections for high resistance using one of the following methods:

a) Use of low-resistance ohmmeter

b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS- 2021, Table 100.12.

c) Perform thermographic survey in accordance with below Section Thermographic Survey.

4) Inspect compression-applied connectors for correct cable match and indentation.

5) Inspect for correct identification and arrangements.

6) Inspect cable jacket insulation and condition.

b. Electrical Tests

1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.

a) Motor feeders tested with motors disconnected and controller open.

b) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.

c) Panelboard feeders tested with feeder breaker open and panel-board connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.

d) Conductors of main lighting feeders, including lighting panel with branch circuits open.

e) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid state device.

f) Equipment which may be damaged during this test shall be disconnected.

g) The Engineer shall be consulted if minimum insulation values cannot be obtained.

2) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3) Perform continuity test to insure correct cable connection.

c. Test Values – Visual and Mechanical

1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels should be in accordance with NETA ATS-2021, Table 100.12 unless otherwise specified by the manufacturer.

3) Results of the thermographic survey shall be in accordance with the below Section Thermographic Survey.

d. Test Values – Electrical

1) Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS-2021 Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.

3) Cable shall exhibit continuity.

4) Deviations in resistance between parallel conductors shall be investigated.

6. Cables, Medium and High-Voltage

a. Visual and Mechanical Inspection

1) Compare cable data with drawings and specifications.

2) Inspect exposed sections of cables for physical damage.

3) Inspect bolted electrical connections for high resistance using one of the following methods:

a) Use of low-resistance ohmmeter.

b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS- 2021, Table 100.12.

c) Perform thermographic survey in accordance with below section Thermographic Survey.

4) Inspect compression-applied connectors for correct cable match and indentation.

5) Inspect shield grounding, cable support, and termination.

6) Verify that visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.

7) If cables are terminated through window-type current transformers, make an inspection to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.

8) Visually inspect jacket and insulation condition.

9) Inspect for correct identification and arrangements.

b. Electrical Tests

1) Perform a shield-continuity test on each power cable by ohmmeter method.

2) Perform an insulation-resistance test utilizing a megohmmeter with a voltage output of at least 2500 volts. Individually test each conductor with all other conductors and shields grounded. Test duration shall be one minute.

3) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

4) Perform a VLF (very low frequency) test of the medium voltage cables in accordance with IEEE Standard 400.2-2013.

c. Test Values

1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels should be in accordance with NETA ATS-2021, Table 100.12 unless otherwise specified by manufacturer.

3) Microhm or millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

4) Shielding shall exhibit continuity. Investigate resistance values in excess of ten ohms per 1000 feet of cable.

5) In order to be acceptable, the cable must withstand the test high voltage without breakdown, have steady or decreasing leakage current during the high potential test, and have satisfactory comparable megger readings in each megger test. Test results shall be submitted to the ENGINEER, stating equipment used and time of test.

7. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

8. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:

a. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.

b. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 26 05 73 – Protective Device Studies.

c. Setting of protective relays in conformance with results of the Short Circuit Study required by Section 26 05 73 - Protective Device Studies and testing of relays to assure that relays will trip at the current value and time required by the Study.

d. Circuit Breakers

1) Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.

2) Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.

3) Setting shall be tabulated and proven for each circuit breaker in its installed position.

4) Test results shall be certified by the person performing the tests and shall be submitted to the ENGINEER.

9. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

C. Metering and indication lights for motors and other devices shall be tested for proper operation.

D. All control circuits such as motor, interlock and remote shall be tested for proper operation.

E. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

F. All lighting panels, circuits and fixtures; and power panels, circuits and receptacles shall be tested for proper operation.

G. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results

1. Visual and Mechanical Inspection

a. Verify ground system is in compliance with drawings and specifications.

2. Electrical Tests

a. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81 on the main grounding electrode or system.

b. The earth resistance of each ground electrode shall be measured and recorded before electrodes are connected to the grounding loop.

c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

3. Test Values

    a. The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner.

    b. Investigate point-to-point resistance values which exceed 0.5 ohm.

H. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

I. THERMOGRAPHIC SURVEY

1. Visual and Mechanical Inspection

    a. Inspect physical, electrical, and mechanical condition.

    b. Remove all necessary covers prior to thermographic inspection. Utilize appropriate caution, safety devices, and personal protective equipment.

2. Equipment to be inspected shall include all 120 volt and higher current-carrying devices including all switchgear, switchboards, distribution panels, cable and bus connections, motor control centers and starters, disconnect switches, and other critical equipment. Testing of lighting luminaires, field instrumentation, SCADA & PLC's are not required.

3. Provide report including the following:

    a. Description of equipment to be tested.

    b. Discrepancies.

    c. Temperature difference between the area of concern and the reference area.

    d. Probable cause of temperature difference.

    e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.

    f. Identify load conditions at time of inspection.

    g. Provide photographs and/or thermograms of the deficient area.

    h. Recommended action.

4. Test Parameters

    a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.

    b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.

c. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Refer to ANSI/NFPA 70B-2010, Section 11-17 (Infrared Inspection).

5. Test Values

a. Suggested actions based on temperature rise can be found in Table 100.18.

6. RE-INSPECTION

a. All items that are reported deficient in the thermography reports section of the inspection report shall be re-inspected after repairs have been made.

b. Original specification will apply to re-inspections.

c. Submit re-inspection reports and indicate that repairs have fixed the anomaly or indicate any remaining anomalies.

2.3 TEST REPORTS

A. The test report shall include the following:

1. Summary of project.

2. Description of equipment tested.

3. Description of test.

4. Test data.

5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.

2. Equipment identification.

3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.

4. Date of inspections, tests, maintenance, and/or calibrations.

5. Identification of the testing technician.

6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.

8. Indication of “as-found” and “as-left” results.

9. Sufficient spaces to allow all results and comments to be indicated.

C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

TABLE 100.18

THERMOGRAPHIC SURVEY
SUGGESTED ACTIONS BASED ON TEMPERATURE RISE

Temperature difference (ΔT) based on comparisons between similar components under similar loading.	Temperature difference (ΔT) based upon comparisons between component and ambient air temperatures.	Recommended Action
1ºC - 3ºC	1ºC - 10ºC	Possible deficiency; warrants investigation
4ºC - 15ºC	11ºC - 20ºC	Indicates probable deficiency; repair as time permits
- - - - - -	21ºC - 40ºC	Monitor until corrective measures can be accomplished
>15ºC	>40ºC	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on ΔT. In the absence of consensus standards for ΔT, the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Chapter 8.9.2, Conducting an IR Thermographic Inspection, *Electrical Power Systems Maintenance and Testing*, by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology

PART 3 -- TEST RECORD SHEETS

The test record sheets listed below shall be used to record testing of electrical equipment and of the electrical installation as required by these specifications. Sample copies of each sheet are attached.

Sheet No.	Title
1	Insulation Resistance (Power, Control Wire, and Cable) Test Record
2	Insulation Resistance (Instrument Wire and Cable) Test Record
3	Ground Electrode Testing Test Record
4	Bonding Resistance Readings (Nonelectrical Equipment/Structures) Test Record
5	Bonding Resistance Readings (Electrical Equipment) Test Record
6	Insulation Resistance (Transformer) Test Record
7	Insulation Resistance (Equipment) Test Record
8	Insulation Resistance (Rotating Equipment) Test Record
9	Breaker/Contactor (4160 V MCC) Test Record
10	208 V Motor Circuit Test Record
11	Thermographic Test Record

INSULATION RESISTANCE
(POWER, CONTROL WIRE, AND CABLE)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: ___ ºC _____ ºF DATE: _____

NOTES: 1. Perform Insulation Resistance Test (megger) between each conductor and all other conductors and metallic sheath for cables with nonshielded conductors. Test between each conductor and shield for multiconductor cables with shielded conductors. Record lowest reading for each cable.

2. Use 1,000-V test set for cable rated 600 volts and 2,500-V test set for cable rated over 600 volts.

3. Readings will vary inversely with temperature and cable length. When the use of temperature correction factors is specified, attach a second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Panel No. Circuit No. Feeder No.	Wire Tagging	Cable Rated Voltage	Wire or Cable Quantity	Insulation Size	From	To	Resistance (megohms)*	Initials

*Minimum acceptable values:

Cable Rated Voltage	Test Duration	Resistance for Cable Only	Cable/Wire Size or Amperage (megohms)	Resistance When Cable Connected to Equipment (ohms)

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE
(INSTRUMENT WIRE AND CABLE)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

NOTES: 1. Record only the lowest value.

2. MP - Multi-pair cable. SP - Single pair cable.
3. Megger with instruments disconnected.
4. Use 250 volt (or lower voltage, when specified) range on DC test set.
5. Readings will vary with temperature and cable length.*

Cable Number or Instrument Number	Indicate MP or SP Type (2)	Conductor to Conduit (Single Pair Non-Shielded Cables) (megohms)	Conductor to Conductor (megohms) (1)	Shield to Conductor to Shield (megohms) (1)	Overall Shield to Shield (Multipair Cables Only) (megohms) (1)	Lead and Armor (Multipair Cables Only (megohms)	Shield to Conduit (Single Pair Cables Only) (megohms)	Initials

DISTRIBUTION:

CONTRACTOR/Date _____

GROUND ELECTRODE TESTING
TEST RECORD

TEST EQUIPMENT: _____ (Note 1) _____ (Note 2)

REFERENCE DRAWING: _____ _____

NOTES: 1. Record resistance-to-earth for each electrode with all other conductors disconnected. Resistance not to exceed 25 ohms for any single anode.

2. Check continuity from each electrode to any test bar or other electrode such that the complete ground loop is tested.

Rod Number	Resistance to Earth (ohms)	Ambient Temperature (ºC/ºF)	Weather	Taps (□)	Initials/Date

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS
(NONELECTRICAL EQUIPMENT/STRUCTURES)
TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES: 1. Vessels, tanks, and structural steel bonded to the main grounding system, dedicated ground rod or foundation, as indicated on drawings listed below.

2. Measure resistance from ground wire tap (or anchor bolt) to tagged equipment frame or structural steel.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS
(ELECTRICAL EQUIPMENT)
TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES: 1. Electrical equipment bonded to the main grounding system or dedicated ground rod, as indicated on drawings listed below.

2. Measure resistance from ground wire tap to tagged equipment bus bars, tagged equipment enclosures, and any other points indicated on the drawings.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE
(TRANSFORMER)
TEST RECORD

SUBSTATION NO.: _____ TEST EQUIPMENT: _____

NOTES:
1. Use 1,000-V test set for 600-volt equipment and below, 2,500-V test set for equipment rated 601 - 5,000 volts, and 5,000-V test set for equipment rated over 5,000 volts.
2. Test voltage to be applied for 1-minute duration, and reading taken.
3. Neutral must be disconnected from ground during test.
4. Record temperature of surrounding air temperature for dry-type transformers.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equipment Tag No.	RESISTANCE IN (megahoms) *						Pri to Sec	Voltage Rating (kV)	Pri-Sec or Air	Liquid Temp. (ºC/ºF)
	Primary			Secondary						
	∅A to G	∅B to G	∅C to G	∅A to G	∅B to G	∅C to G				

*Minimum acceptable values:

VOLTAGE CLASS	RESISTANCE (megohms)

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE (EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: _____ SUBSTATION: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

REFERENCE DRAWING: _____ REF. SEC.: _____

NOTES: 1. Use 1,000-V test set for equipment rated 600 volts and below, 2,500/5,000-V test set for equipment rated over 600 volts.

2. For equipment with solid state control circuits, consult manufacturer's literature for maximum test voltages.

Switchgear MCC (other)	INSULATION RESISTANCE (megohms) *						Test Voltage (kV)	Rated Voltage (kV)	Initials/ Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A			

*Minimum acceptable values:

EQUIPMENT VOLTAGE CLASS (megohms)	RESISTANCE

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE (ROTATING EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

EQUIP. TEMP., IF KNOWN: _____ ºC _____ ºF HOW KNOWN: _____

NOTES:
1. Use 1,000-V test set for equipment 600-volt and below, 2,500/5,000-V test set for equipment rated over 600 volts.
2. Test duration shall be 1 minute, note if otherwise: _____.
3. Isolate all motor leads from one another and from frame, test phase separately, wherever practical.
4. Document testing of low voltage and medium voltage equipment on separate sheets.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equipment Tag No.	INSULATION RESISTANCE (megohms) *						Rated Voltage	Equipment Initial/Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A		

*Minimum acceptable values:

VOLTAGE CLASS	RESISTANCE (megohms)

DISTRIBUTION:

CONTRACTOR/Date _____

BREAKER/CONTACTOR (4160 V MCC)
TEST RECORD

EQUIPMENT DESIGNATION			
LOAD (kW/kVA)		VOLTAGE	F.L.A.
CIRCUIT BREAKER MFG.		RATING	SETTING
CONTACTOR MFG.		SIZE	
CONDUCTOR SIZE	POWER	CONTROL	GROUND

1. Check nameplate data of breaker, contactor fuses and relays against approved vendor drawings. _____
2. Check main and auxiliary contacts. _____
3. Check contactor/breaker components for cleanliness. _____
4. Check control fuses, CPT rating, and coil voltage. _____
5. Check mechanical function of contactor and breaker. _____
6. Check wiring for proper identification. _____
7. Check conduits/cables for tagging. _____
8. Check components for identification. _____
9. Check equipment for conformance to area classification. _____
10. Check installation for seals, breathers, and drains. _____
11. Verify continuity of all power and control leads. _____
12. Check that power and control cable Insulation Resistance Test (megger) is completed. _____
13. Complete functional operation check of the control circuit using contract drawings and approved vendor drawings. Close and open the contactor using all control devices. _____

DISTRIBUTION:

CONTRACTOR/Date _____

208 V MOTOR CIRCUIT
TEST RECORD

EQUIPMENT DESIGNATION			
MOTOR TAG NO.		VOLTAGE	F.L.A.
KW/HP		RPM	S.F.
CIRCUIT BREAKER MFG.		RATING	SETTING
STARTER MFG.		SIZE	O/L HTR. SIZE
C.T. RATIO		O/L RELAY SETTING	
CONDUCTOR SIZE	POWER	GROUND	

1. Check motor starter for cleanliness. _____

2. Check nameplate data and tagging of motor starter components for conformance to approved vendor drawings. _____

3. Check conduits and/or cables for correct tagging. _____

4. Check equipment and installation for conformance to area classification. _____

5. Check main and auxiliary contacts of breaker and contactors. _____

6. Manually check mechanical operation of breaker, contactor, O/L relay, and O/L reset device. _____

7. Check continuity of power and control cables. _____

8. Complete functional operation check of the motor control circuit using the contract drawings and approved vendor drawings. Close and open the starter using all control devices. _____

9. Verify proper operation of motor winding space heater unit. _____

DISTRIBUTION:

CONTRACTOR/Date _____

THERMOGRAPHIC INSPECTION
TEST RECORD

EQUIPMENT: _____

THERMAL AND ELECTRICAL INFORMATION

THERMAL DATA (°F/°C) AND RISE				MANUAL READINGS			
A Phase	____/____	Reference	_____°F	A Phase	_____ A	A/ B Volts	_____V
B Phase	____/____	Temperature	_____° C	B Phase	_____ A	B/C Volts	_____V
C Phase	____/____	ΔT	_____°F	C Phase	_____ A	A/C Volts	_____V
Neutral	____/____	or Rise	_____° C	Neutral	_____ A	A/N Volts	_____V
ANOMALY TEMP(°F/°C)							
PROBLEM DESCRIPTION:							
RECOMMENDATION:							

ANOMALY PRIORITY

CRITICAL - IMMEDIATE ATTENTION SUGGESTED

SEVERE - PROBABLE FAILURE, PROMPT ACTION RECOMMENDED

INTERMEDIATE - MONITOR PROBLEM, SCHEDULE MAINTENANCE

MINOR - SCHEDULE ROUTINE MAINTENANCE AT NEXT OPPORTUNITY

DISTRIBUTION:

CONTRACTOR/Date _____

END OF SECTION

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SECTION 26 05 10 - ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide electric motors, accessories, and appurtenances complete and operable, in conformance to the Contract Documents.

B. The provisions of this Section apply to low voltage 3 phase, AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.

C. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:

1. Machine name and specification number of driven machine
2. Motor manufacturer
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower
5. NEMA design
6. Enclosure
7. Frame size
8. Winding insulation class and temperature rise class
9. Voltage, phase, and frequency ratings
10. Service factor
11. Full load current at rated horsepower for application voltage
12. Full load speed
13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.
14. Type of thermal protection or overtemperature protection, where included
15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable

16. Bearing data. Include recommendation for lubricants of relubricatable type bearings.

17. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding details and information. Provide insulated bearing details and information.

18. Power factor at 1/2, 3/4 and full load.

19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electric motors driving identical machines shall be identical.

B. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.

C. Motor Capacity

1. The CONTRACTOR shall size motors for the larger of the following criteria:

a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.

b. Size motors for minimum size indicated

2. In every case, motor size shall be derated from nameplate values as follows:

a. Ambient Temperature

1) For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.

2) For ambient temperatures exceeding 40 degrees but less than 50 degrees C, derate nameplate HP ratings to 85 percent.

b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters). Higher altitudes require the following derating factors:

Altitude	Derating Factor
3,300 to 5,000 ft	97 percent
5,001 to 6,600 ft	94 percent

6,601 to 8,300 ft	91 percent
8,301 to 9,900 ft	88 percent
9,901 to 11,500 ft	85 percent

3. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the WORK.

D. Exempt Motors: Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.2 DESIGN REQUIREMENTS

A. General: Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31, and shall be clearly identified as “Inverter Duty.”

B. NEMA Design: Electric motors shall be NEMA Design B unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.

C. Motor Voltage Ratings: Low voltage motors shall have voltage ratings in accordance with the following, unless otherwise indicated:

1. Motors below 1/2 HP shall be rated 115 volts, single phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.

2. Motors 1/2 HP and larger shall be rated 208 volts, 3 phase, 60 Hz. Dual voltage motors rated 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.

D. Insulation: Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class.

E. Motors 50 HP or smaller located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 unless otherwise indicated.

F. NEMA Premium Efficiency Motors

1. Motors with a nameplate rating of 1 HP and larger shall be NEMA premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.

2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with the following tables. Both efficiencies shall be included in the Shop Drawing submittal.

OPEN DRIP-PROOF (ODP)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		**4 POLE**		**6 POLE**	
HP	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	86.5	84.0
2	85.5	82.5	86.5	84.0	87.5	85.5
3	85.5	82.5	89.5	87.5	88.5	86.5
5	86.5	84.0	89.5	87.5	89.5	87.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5
10	89.5	87.5	91.7	90.2	91.7	90.2
15	90.2	88.5	93.0	91.7	91.7	90.2
20	91.0	89.5	93.0	91.7	92.4	91.0
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	94.1	93.0	93.6	92.4
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.0	94.1	94.5	93.6
100	93.6	92.4	95.4	94.5	95.0	94.1
125	94.1	93.0	95.4	94.5	95.0	94.1
150	94.1	93.0	95.8	95.0	95.4	94.5
200	95.0	94.1	95.8	95.0	95.4	94.5
250	95.0	94.1	95.8	95.0	95.8	95.0
300	95.4	94.5	95.8	95.0	95.8	95.0
350	95.4	94.5	95.8	95.0	95.8	95.0
400	95.8	95.0	95.8	95.0	--	--
450	96.2	95.4	96.2	95.4	--	--
500	96.2	95.4	96.2	95.4	--	--

Source: NEMA MG1 - 2011, Table 12-12

TOTALLY ENCLOSED - FAN COOLED (TEFC)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		**4 POLE**		**6 POLE**	
HP	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5
2	85.5	82.5	86.5	84.0	88.5	86.5
3	86.5	84.0	89.5	87.5	89.5	87.5
5	88.5	86.5	89.5	87.5	89.5	87.5
7.5	89.5	87.5	91.7	90.2	91.0	89.5
10	90.2	88.5	91.7	90.2	91.0	89.5
15	91.0	89.5	92.4	91.0	91.7	90.2
20	91.0	89.5	93.0	91.7	91.7	90.2
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	93.6	92.4	93.0	91.7
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.4	94.5	94.5	93.6
100	94.1	93.0	95.4	94.5	95.0	94.1
125	95.0	94.1	95.4	94.5	95.0	94.1
150	95.0	94.1	95.8	95.0	95.8	95.0
200	95.4	94.5	96.2	95.4	95.8	95.0
250	95.8	95.0	96.2	95.4	95.8	95.0
300	95.8	95.0	96.2	95.4	95.8	95.0
350	95.8	95.0	96.2	95.4	95.8	95.0
400	95.8	95.0	96.2	95.4	--	--
450	95.8	95.0	96.2	95.4	--	--
500	95.8	95.0	96.2	95.4	--	--

Source: NEMA MG1 - 2011, Table 12-12

G. Two speed motors shall be of the 2 winding type.

2.3 ACCESSORY REQUIREMENTS

A. General: Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors shall be provided with oversized conduit boxes. Where conduit sizes indicated do not match the motor terminal box, the CONTRACTOR shall provide means to accommodate the motor requirements. Motor boxes other than open drip-proof shall be gasketed.

B. Lifting Devices: Motors weighing 265 lb (120 Kg) or more shall have suitable lifting eyes for installation and removal.

C. Special Requirements: The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.

D. Grounding Lugs: Provide motor grounding lug suitable to terminate ground wire, sized as indicated.

E. Nameplate: Motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40. Inverter duty motors shall be clearly identified as such.

F. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close the contacts when the motor is at zero speed.

2.4 MOTOR THERMAL PROTECTION

A. Single Phase Motors: Single phase 120, 208, or 230 volt motors shall have integral thermal overload protection or shall be inherently current limited.

2.5 MOTOR BEARINGS

A. General: Bearings shall conform to Section 46 01 00 - Equipment General Provisions, except as indicated herein.

B. Motors greater than 2 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.

C. Fractional Horsepower: Motors with fractional horsepower through 2 HP shall be provided with lubricated-for-life ball bearings.

D. Horizontal Motors Over 2 HP: Motors larger than 2 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

E. Vertical Motors Over 2 HP: Vertical motors larger than 2 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

F. Water Cooled Motors: If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow

indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.

G. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.6 MANUFACTURERS, OR EQUAL

A. **U.S. Motors/Nidec**

B. **Baldor**

C. **WEG**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment. Shaft grounding devices shall be connected to the grounding system in accordance with the manufacturer's recommendations.

B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 26.

3.2 FACTORY TESTING

A. Provide standard factory test for each motor on this project.

3.3 FIELD TESTING

A. The CONTRACTOR shall perform the following field tests (see also Section 26 01 26 – Electrical Testing):

1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.

2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.

3. Check winding and bearing temperature detectors and space heaters for functional operation.

4. Test for proper rotation prior to connection to the driven equipment.

5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.

6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 500 VDC plus twice the rated voltage of the motor.

END OF SECTION

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SECTION 26 05 15 – INDUSTRIAL CONTROL PANELS AND MISCELLANEOUS ELECTRICAL DEVICES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide complete industrial control panels and/or local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in Section 40 91 00 – Process Control and Instrumentation Systems and the P&ID Drawings.

B. This section also specifies miscellaneous electrical devices used throughout this project. These devices are not limited to use within industrial control panels or local control stations.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Industrial control panels and/or local control stations shall comply with the requirements of NEC (including Article 409), NEMA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General.

1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.

2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide the equipment, panels and stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL labeled components. Equipment not specifically indicated as being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.

B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, 3 phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 26 05 19 –Wire and Cabling.

C. Each panel and/or station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The panels and/or stations shall be the source of power for all 120 VAC solenoid valves interconnected with the panels

and/or stations. Equipment associated with the panels and/or stations shall be ready for service after connection of conductors to equipment, controls, panels and/or stations.

D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.

E. Enclosures

1. In finished rooms, enclosures shall be NEMA 12 steel enclosures painted with ANSI 61 exterior and white interior.

2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure, subject to approval by the ENGINEER.

3. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.

F. Disconnect Switches

1. Heavy duty, non-fusible, single throw switches shall be rated not less than 10 KA at 480 VAC.

2. Heavy duty, fusible, single throw switches shall be rated not less than 65 KA at 480 VAC.

3. Horsepower rated

4. UL listed

5. Padlockable in "Off" position and door interlock

6. Enclosure per area classification in Section 26 00 00 – Electrical Work, General.

7. 480 V, 3-phase, 3-pole (6-pole when used with 2-speed motor).

8. Auxiliary control contact as applicable and where indicated.

9. As manufactured by **G.E., Eaton Electrical, Square D,** or equal.

G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 26 00 00 – Electrical Work, General.

H. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation, but not higher than 6’-6” above finished floor, unless noted otherwise.

I. MODIFICATIONS TO EXISTING 5KV STARTER SWITCHGEAR

1. The existing 5 kV starter switchgear lineup shall be modified as indicated on the drawings. A new fused drawout latching 400 ampere vacuum contactor, fuses,

controls, protective relay, and related appurtenances shall be provided to feed the new step-down transformer.

2. Modifications to the existing starter switchgear shall be made by an authorized service representative of the manufacturer of the existing equipment, and shall be by **Eaton Service**.

3. Components shall be new. Used, repurposed, remanufactured or rehabilitated equipment shall not be acceptable.

4. All wires shall have unique wrap-around tags and terminals shall be clearly identified with unique numbers corresponding to the shop drawings. Spare wires shall be terminated to terminal strips.

5. The existing nameplate information is as follows:

   a. Manufacturer: Westinghouse (now Eaton)

   b. Catalog Number: VM02S04GG

   c. Manufacture Date: March, 1991

   d. Order Number: CG11170-1A

   e. Compartment Number: 11F

2.2 PANEL/STATION COMPONENTS

A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **General Electric, Eaton Electrical, Square D,** or equal.

   1. Lens colors shall be red for "run," "open," or "on"; green for "stopped," "closed," or "off"; and amber for alarm.

   2. Pilot lights shall be full voltage, push-to-test, LED cluster type.

B. Relays shall be 3 PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Potter Brumfield,** or equal.

C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **General Electric, Eaton Electrical,** or equal.

D. Magnetic starters shall be:

   1. NEMA rated, Size 1 minimum. IEC or dual NEMA/IEC rated type are not acceptable.

   2. FVNR type unless indicated otherwise.

   3. Combination starters with magnetic only instantaneous trip circuit breakers such as **Eaton Electrical HMCP, General Electric Mag-Break,** or equal. Breakers shall be rated 65 KA minimum.

4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.

E. Terminal strips shall be provided for every panel and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.

F. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D, ATC, Eaton Electrical,** or equal.

2.3 FACTORY TESTING

A. Each panel/station shall be factory assembled and tested for sequence of operation prior to delivery.

2.4 SPARE PARTS

A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color pilot lamp in each panel.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Panels/stations shall be installed in accordance with in Section 26 00 00 – Electrical Work, General and in accordance with the manufacturer's recommendations.

B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.

C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.

D. Conduit, conductors, and terminations shall be installed in accordance with Section 26 00 00 – Electrical Work, General.

3.2 FIELD TESTING

A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

SECTION 26 05 19 - WIRE AND CABLING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.

B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower in accordance with Section 26 05 10 – Electric Motors. Revisions are part of the WORK of this Section.

1.2 ACTION SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General. Submit cable test results in accordance with this Section as well as Section 26 01 26 – Electrical Tests.

1.3 DELIVERY, STORAGE AND HANDLING

A. The CONTRACTOR shall protect all cables from damage at all times.

B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become submerged prior to splicing or termination, the cables shall be replaced in their entirety.

C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.

D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

B. Low Voltage Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be single conductor, Class B Type XHHW or XHHW-2 cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables.

THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels per Section 40 95 13 – Control Panels.

2. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

3. Conductors for branch circuits as defined in Article 100 of the NEC shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

4. Wiring for 600 volt class power and lighting shall be as manufactured by **Okonite**, **General Cable**, **Southwire**, or equal.

C. Low Voltage Control Wire

1. Low voltage control wire in duct or conduit shall be the same type as power and lighting wire indicated above.

2. Control wiring shall be No.14 AWG.

3. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by **American, General Cable,** or equal.

D. Instrumentation Cable

1. Instrumentation cable shall be rated at 300 volts, minimum.

2. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-clear for 2 conductor cable and black-red-clear for 3 conductor cable.

3. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 or larger AWG stranded, tinned copper drain wire, and a PVC outer jacket with a thickness of 0.047-inches.

4. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8719,** similar by **General Cable,** or equal.

5. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8618,** similar by **General Cable,** or equal.

E. Medium Voltage Cable - General

1. Individual conductors shall be copper, Class B, stranded.

F. Medium Voltage - 5 KV Cable

1. Cable used in conduit or duct shall be composed of a single conductor, ethylene-propylene rubber (EPR) insulation rated at 105 degrees C, shield, and black polyvinyl chloride (PVC) jacket. Insulation level shall be 133 percent, 115 mil. Shield shall be copper tape type, or corrugated drain wire type. Cable shall be UL Type MV-105 in accordance with UL 1072 and ICEA-S-93-639/NEMA-WC74 - Medium Voltage Power Cables, as manufactured by **Okonite, Southwire**, **General Cable,** or equal.

G. Cable Splices and Terminations

1. Where cable lugs are required for power cable terminations, utilize compression lugs – **3M** Scotchlok 30000 and 31100 Series, **Penn Union** HBBLU and BLU, **Burndy** Hylug, or equal. Utilize compression tools as recommended by the manufacturer. Pressure type, twist-on connectors (wire nuts) will not be acceptable.

2. Pre-insulated fork tongue lugs shall be **Thomas & Betts, Burndy**, or equal.

3. General purpose insulating tape shall be **Scotch No. 33**, **Plymouth Slip-knot**, or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth, 3M,** or equal.

4. Labels for coding 600 volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by **W.H. Brady, 3M**, or equal.

5. Stress cone material for make-up of medium voltage shielded cable shall be as manufactured by **Raychem, 3M**, or equal.

6. Shielded power cable shall be spliced using kits specifically designed to splice medium voltage, shielded power cables. Splice kits shall be designed for continuous submergence. Heat shrink splice kits shall be **Raychem "Type HVS"**, or equal. "Cold" shrink splice kits shall be **3M "5760 Series",** or equal. The CONTRACTOR's personnel shall be trained by the splice kit manufacturer for proper installation of the splices, and shall submit certification of training as a shop drawing. A certified trainee shall perform the splice work.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall provide, terminate and test all power, control, and instrumentation conductors.

B. The CONTRACTOR shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.

C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.

D. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.

E. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.

F. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

3.2 FIELD ASSEMBLY

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.

2. In general, there shall be no cable splices in underground manholes or pullboxes. If splices are necessary, the cables shall be spliced using submersible cable splices, suitable for continuous submergence. Splices in underground manholes and pullboxes may be made only with the approval of the ENGINEER.

3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In motor control centers, and control panels, control wire and spare wire shall be terminated to terminal strips.

3. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as spares.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.

2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes with the prior approval of the ENGINEER. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, 120/240-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR. Cables rated above 2,000 volts shall be spliced or terminated only at equipment terminals indicated.

2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of

varnished cambric tape overtaped with a minimum of 2 layers of high temperature tape.

3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.

E. Cable Identification

1. General: Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort. Identification shall be installed at every termination point.

2. Identification Numbers: The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3-inches of conductor terminals. "Control and Instrumentation Conductors" shall be defined as any conductor used for control, interlock, alarm, annunciator, or signal purposes.

   a. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.

   b. 120/208-volt system feeder cables and branch circuit conductors shall be color coded as follows: Phase A - black, Phase B - red, Phase C - blue, and Neutral - white. The 120/240-volt system conductors shall be color coded as follows: Line 1 - Black, Line 2 - Red, and Neutral - White. The 480/277-volt system conductors shall be color coded as follows: Phase A - Brown, Phase B - Orange, Phase C - Yellow, and Neutral - Gray. Branch circuit switch shall be yellow. Insulated ground wire shall be green, and neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs. Color coding tape shall be used where colored insulation is not available. Colored identification tape may be used on conductors between the local disconnect and the load, where permitted by the NEC. Any phase changes necessary for proper rotation shall be made at the driven equipment where colored insulation is used. Phase changes may be made on the load side of the local disconnect, where phase colors are identified using tape.

   c. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.

   d. Spare cable shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.

   e. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.3 FIELD QUALITY CONTROL

A. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-95-658/NEMA WC70 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Factory test results shall be submitted in accordance with Section 01 33 00 – Contractor Submittals, prior to shipment of cable. The following field tests (in addition to the tests specified in Section 26 01 26 – Electrical Tests) shall be the minimum requirements:

1. Insulation resistance testing, using a DC megohmeter, shall be performed on cables operating at more than 2,000 volts to ground. Time-resistance readings shall be taken and recorded at intervals of 30 seconds and one minute. Time-resistance voltage levels shall be per the cable manufacturer's recommendations.

2. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmeter.

3. Field testing shall be done after cable is installed in the raceways.

4. Field tests shall be performed by a NETA-certified test organization. Field megger testing may be performed by the CONTRACTOR or a NETA-certified test organization. When tested by the CONTRACTOR, submit test equipment calibration sheets prior to performing any field testing. Test results shall be submitted to the ENGINEER for review and acceptance.

5. Cables failing the tests shall be replaced with a new cable or be repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.

B. Continuity Test: Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

END OF SECTION

SECTION 26 05 26 – GROUNDING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 ACTION SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals and Section 26 00 00 – Electrical Work, General.

1. Include with each submittal a copy of this specification section, with addenda updates included, and all referenced and applicable sections included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Shop Drawings

1. Submit manufacturer's product information for connectors, clamps, and all grounding system components, showing compliance with the requirements of this Section.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.

B. Grounding System

1. Grounding loop conductors shall be bare annealed tin-plated copper conductors.

2. Conductors shall be No. 4/0 unless indicated otherwise.

3. Ground Rods

    a. Unless indicated otherwise, provide ground rods minimum of 3/4 inch in diameter, 10 feet long, and with a uniform covering of electrolytic copper metallically bonded to a rigid steel core.

    b. Provide corrosion-resistant copper-to-steel bond.

    c. The rods shall conform to UL 467.

    d. The rods shall be of the sectional type, joined by threaded copper alloy couplings.

4. Make buried, concrete-encased, or otherwise inaccessible cable-to-cable and cable-to-ground rod connections using exothermic welds by **Cadweld, Thermoweld,** or equal. Alternatively, non-reversible, compression connectors may be used for inaccessible grounding connections, constructed of high-copper alloy, and manufactured specifically for the particular grounding application. The connectors shall be **Burndy "Hyground"**, similar by **Thomas and Betts**, or equal.

5. Exposed Connectors

    a. Exposed grounding connectors shall be of the compression type (connector-to-cable), constructed of high-copper alloy, and manufactured specifically for the particular grounding application.

    b. The connectors shall be **Burndy, O.Z. Gedney**, or equal.

6. Use grounding clamps to bond each separately-derived system to the grounding electrode conductors.

7. Equipment Grounding Circuit Conductors

    a. The conductors shall be the same type and insulation as the load circuit conductors.

    b. The minimum size shall be as indicated. Where not indicated, sizes shall conform to Table 250.122 of the National Electrical Code.

    c. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.

8. Grounding Materials Manufacturer, or Equal

    a. Copperweld

    b. Thermoweld

    c. Burndy

    d. Thomas and Betts

    e. OZ Gedney

PART 3 -- EXECUTION

3.1 PREPARATION

A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

B. Provide a separate grounding conductor for each motor and connect at motor box. Provide a supplemental ground connection for motor shaft grounding rings, where applicable.

C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.

D. Sizes shall be as indicated on the Conduit Schedule and in accordance with NEC Article 250.

E. Route the conductors inside the raceway.

F. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or panelboard.

G. Individually bond the raceway to the ground bus in the secondary section.

H. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw, and, for grounding type devices, to the equipment grounding conductor.

I. Provide a separate grounding conductor in each individual raceway for parallel feeders. Connect the parallel ground conductors together at each end of the parallel run, as required by the NEC.

J. Interconnect the secondary switchgear MCC or panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point. For wye connected, 3 phase, separately derived systems with 3 wire distribution, connect the transformer neutral to the grounding electrode system at the transformer. Connections shall be in accordance with the NEC.

K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.

L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system. Provide additional grounding system testing in accordance with Section 26 01 26 – Electrical Tests.

M. Low Voltage Grounded System (600V or less)

1. A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded.

2. Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.

3. The grounded circuit conductor shall not be used for grounding non-current-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

N. Embedded Ground Connections

1. Underground and grounding connections embedded in concrete shall be UL-listed ground grid connectors.

2. The connection shall be made in accordance with the manufacturer's instructions.

3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.

O. Ground Ring

1. Furnish trenching and materials as necessary to install the ground ring as indicated.

2. The bonding conductor shall be in direct contact with the earth and of the indicated size.

3. Provide a minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.

4. Re-compact disturbed soils to their original density in 6-inch lifts.

P. Duct Bank Ground

1. Embed a grounding conductor in every duct bank as indicated. The ground conductor shall be terminated at the ground grid at each end of the duct bank. Where no ground grid is installed, terminate at a suitable grounding electrode conductor near the end of the duct bank in accordance with the NEC.

Q. Ground Rods

1. Provide ground rods at the indicated locations.

2. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.

3. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.

4. Rods forming an individual ground array shall be equal in length.

R. Instrumentation Shield Grounding

1. Shielded instrumentation cable shall have its shield grounded at one end only unless the approved Shop Drawings indicate that the shield will be grounded at both ends.

2. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.

4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor.

5. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

END OF SECTION

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SECTION 26 05 33 - ELECTRICAL RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide electrical raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the WORK.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals, and Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

2. Submit dimensioned layout drawings of cable tray routings, including elevations.

3. As-Built Drawings

a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.

2.2 CONDUIT

A. Rigid Aluminum (RAL) Conduits

1. Provide rigid aluminum conduit manufactured from 6063 alloy, temper T-1.

2. Provide rigid aluminum conduit manufactured in accordance with NEMA C80.5 – Electrical Rigid Aluminum Conduit, and UL-6A – Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel.

3. Manufacturer, or Equal

a. **V.A.W. of America**

b. **Alcoa**

B. Rigid Galvanized Steel (RGS) Conduit

1. Provide rigid steel conduit manufactured from mild steel, hot-dip galvanized inside and out.

2. Provide rigid steel conduit manufactured in accordance with NEMA C80.1 – Electrical Rigid Steel Conduit, and UL-6 – Electrical Rigid Metal Conduit - Steel.

3. Manufacturer, or Equal

a. **Allied Tube & Conduit**

b. **Triangle**

c. **Wheatland Tube**

C. PVC Rigid Non-Metallic Conduit

1. Provide rigid non-metallic conduit manufactured from Schedule 40 PVC, as indicated, and sunlight-resistant.

2. Provide rigid non-metallic conduit manufactured in accordance with NEMA TC-2 - Electrical Plastic Tubing and Conduit, and UL-651 - Standard for Rigid Non-metallic Conduit.

3. Manufacturer, or Equal

a. **Carlon**

b. **Cantex**

D. Rigid PVC-Coated Galvanized Steel (RPGS) Conduit

1. The conduit shall meet the requirements for RGS conduit as indicated above.

2. Bond a PVC coating to the outer surface of the galvanized conduit.

3. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating.

4. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating.

5. Provide a PVC coating thickness not less than 40 mils.

6. The PVC-coated RGS shall be manufactured in accordance with the following standards:

a. UL-6

b. ANSI C80.1

c. NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

7. Manufacturer, or Equal

a. **Robroy Industries**

b. **O'Kote**

c. **Thomas & Betts**

E. Liquid-Tight Flexible Conduit

1. Provide liquid-tight flexible conduit constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket.

2. Provide liquid-tight flexible conduit manufactured in accordance with the requirements of UL-360 - Steel Conduits, Liquid-Tight Flexible.

3. Manufacturer, or Equal

a. **Anaconda, Sealtite**

b. **Electriflex, Liquatite**

F. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

2.3 FITTINGS AND BOXES

A. General

1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.

2. Fittings and Boxes

a. Provide fittings and boxes with neoprene gaskets and non-magnetic stainless steel screws.

b. Attach covers by means of holes tapped into the body of the fitting.

c. Covers for fittings attached by means of clips or clamps will not be accepted.

3. Provide boxes larger than standard cast or malleable types manufactured of Type 304 or Type 316 stainless steel, NEMA 4X.

4. Terminations

a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, Appleton, or equal.

b. In other than outdoor areas, provide sealed locknuts and bushings.

B. Cast Aluminum Fittings and Boxes

1. Provide cast aluminum boxes and fittings with less than 0.40 percent copper content, and use with aluminum conduit.

2. Manufacturer, or Equal

    a. **O.Z. Gedney**

    b. **Appleton**

    c. **Crouse-Hinds**

C. PVC Fittings and Boxes

1. For use with rigid non-metallic conduit, provide fittings manufactured of solvent-welded PVC.

2. Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).

3. Manufacturer, or Equal

    a. **Carlon**

    b. **Crouse-Hinds**

    c. **Hoffman**

4. Provide welding solvent as required for the installation of non-metallic conduit and fittings.

D. PVC-Coated RGS Fittings

1. For use with PVC-coated RGS, provide PVC-coated coated that are the products of the same manufacturer as the conduit.

2. Provide male and female threads and internal surfaces with a 2-mil urethane coating.

E. Stainless Steel Boxes

1. Provide stainless steel boxes with PVC-coated RGS conduit and where indicated.

2. Provide NEMA 4X stainless steel boxes, constructed of Type 316 stainless steel.

3. Provide stainless steel of a minimum of 14-gauge thickness, with a brushed finish.

4. Door Hinges

    a. Provide doors with full-length stainless steel piano hinges.

    b. Non-hinged boxes will not be accepted.

5. Manufacturer, or Equal

    a. **Hoffman**

b. **Rohn**

c. **Hammond**

F. Sheet Steel Boxes

1. Sheet steel boxes shall be galvanized steel outlet and switch boxes.

2. Manufacturer, or Equal

a. **Raco**

b. **Steel City**

c. **Appleton Electric**

PART 3 -- EXECUTION

3.1 GENERAL

A. Run wiring in raceway unless indicated otherwise.

B. Install raceways between equipment as indicated.

C. Provide raceway systems that are electrically and mechanically complete before conductors are installed.

D. Bends and Offsets

1. Provide bends and offsets that are smooth and symmetrical, and accomplished with tools designed for this purpose.

2. Provide factory elbows wherever possible.

E. Combined Raceways

1. Raceways other than those containing power conductors may be combined in strict accordance with the NEC and with prior written permission from the ENGINEER.

2. In general, combine only raceways containing the same type (control, signal, and the like) and voltage of conductors/cables, or dedicated conduits from one source to one device/equipment, in accordance with the NEC.

3. Permission from the ENGINEER shall not relieve the CONTRACTOR of responsibility to meet national, state and local requirements.

4. Do not combine wiring for redundant systems into single raceways.

F. Routing

1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the

CONTRACTOR's choice and provided in strict accordance with the NEC as well as customary installation practice.

3. Provide the raceway encased, exposed, concealed, or under-floor as indicated, except conceal conduit in finished areas unless specifically indicated otherwise.

4. Adjust routings in order to avoid obstructions.

G. Coordination

1. Coordinate between trades prior to installing the raceways.

2. The lack of such coordination shall not be justification for extra compensation, and any costs for removal and re-installation to resolve conflicts shall be part of the Contract Price.

H. Install exposed raceways parallel or perpendicular to structural beams.

I. Expansion Fittings

1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.

2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur.

3. Encased Expansion Fittings

a. Install encased expansion fittings wherever encased conduits cross building expansion joints.

b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.

4. Provide expansion and expansion/deflection fittings constructed of the same material as the raceway to which they are installed.

J. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

K. Install exposed raceways at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, install exposed raceways at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.

L. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.

3.2 CONDUIT

A. Provide exposed conduit manufactured of rigid aluminum, except as follows and unless indicated otherwise:

1. For conduit containing only grounding system bonding conductors, provide Schedule 80 PVC conduit.

B. Power conduit encased in concrete shall be constructed of Schedule 40 PVC.

C. Analog control or instrumentation conduit shall be RGS.

D. Concrete Encasement

1. Where RGS conduit is stubbed up from a concrete encasement, provide a PVC-coated RGS elbow.

2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.

3. Do not encase conduit in the bottom floor slab below grade.

E. Size

1. Provide exposed conduit of 3/4-inch minimum trade size.

2. Provide encased conduit of one-inch minimum trade size.

F. Install supports at distances required by the NEC.

G. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4 inch for concrete not exposed to weather or in contact with the ground.

H. Penetrations

1. Provide conduit passing through walls or floors with plastic sleeves.

2. Perform core drilling in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

3. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.

I. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:

1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section;

2. Conduits shall not be larger in outside dimension than 1/3 the overall thickness of the slab, wall, or beam in which it is embedded; and,

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

J. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required.

K. Coat threads with a conductive lubricant before assembly.

L. Joints

1. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions in the pipe.

2. Adequately ream the conduit in order to prevent damage to the wires and cables inside.

3. Use strap-wrenches and vises to install the conduit, in order to prevent wrench marks on the conduit.

4. Replace conduit with wrench marks.

5. Where installed in chemical or fuel containment areas, the conduit shall not have joints or fittings located below the top of the containment area to prevent entry of chemicals or fuel into the conduit system.

M. Slope

1. Wherever possible, slope the conduit runs to drain at one or both ends of the run.

2. Wherever conduit enters a substructure below grade, slope the conduit in order to drain water away from the structure.

3. Take extreme care in order to avoid pockets or depressions in the conduit.

N. Where conduits from duct banks enter building walls below grade, transition to PVC-coated RGS at least 12” outside the wall. Installation of PVC-coated rigid steel conduit though a core-drilled hole in an exterior wall below-grade shall utilize a sealing device as manufactured by **Link Seal**, or equal.

O. Connections

1. Make connections to lay-in-type grid lighting fixtures by using flexible metal conduit not exceeding 4 feet in length.

2. Make connections to motors and other equipment subject to vibration by using liquid-tight flexible conduit not exceeding 3 feet in length.

3. Provide equipment subject to vibration that is normally provided with wiring leads with a cast junction box for the make-up of connections.

P. Provide conduit, fittings, and boxes required in hazardous classified areas that are suitably rated for the area, and provide in strict accordance with NEC requirements.

Q. Duct sealant shall be foam duct sealant such as **Polywater FST or approved equal.** Provide duct sealant at the following locations:

1. Where required by NEC Article 300.7.

2. In areas where chlorine gas or fumes from sodium hypochlorite exist to prevent passage of gas through the raceway system.

R. Empty Conduits

1. Tag empty conduits at both ends to indicate the final destination.

2. Where it is not possible to tag the conduit, identify the destination by means of a durable marking on an adjacent surface.

3. Install a pull-cord in each empty conduit in floors, panels, manholes, equipment, and the like.

4. Install a removable plug on empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes.

S. Identification of Conduits

1. Identify conduits at ends and at pulling points.

2. Identification shall be the unique conduit number assigned in the Contract Documents.

3. Other than 120 VAC panelboard circuits, if a conduit has not been assigned a unique number in the Contract Documents, assign a unique number following the numbering scheme used in the Contract Documents.

4. Assign a unique number to 120 VAC panelboard circuits, similar to the cable numbering scheme used in the Contract Documents.

5. Provide conduit identification by a stamped or engraved non-corroding metal tag attached to the conduit bushing.

6. Provide an engraved phenolic nameplate in accordance with the requirements of Section 26 00 00 – Electrical Work, General, or a computer printed self-adhesive label attached to the equipment or enclosure inside which the conduit terminates.

7. Markings with a pen or paint will not be accepted.

T. Identification of Pullboxes and Junction Boxes

1. Identify pullboxes and junction boxes.

2. Identification shall be the unique conduit number assigned in the Contract Documents, or if not assigned a unique number the CONTRACTOR shall assign one following the numbering scheme used in the Contract Documents.

3. Provide box identification by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 26 00 00 – Electrical Work, General, and attached to the box or enclosure.

4. Markings with a pen or paint will not be accepted.

U. Provide conduit for data cables in accordance with the equipment manufacturer's recommendations, especially regarding separation from low- and medium-voltage power raceways.

END OF SECTION

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SECTION 26 05 36 - WIRING DEVICES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

2. Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.

3. Submit documentation of the manufacturer's qualifications.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Devices shall carry the U.L. label, and shall be designed for use with stranded copper conductors.

B. Color

1. General purpose duplex receptacles and toggle switch handles shall be Brown everywhere except unless otherwise indicated.

C. Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.2 LIGHTING SWITCHES

A. Toggle switches shall be AC only type switch.

1. 20A, 120/277V, Single, Double, 3-Way and 4-Way, Respectively

a. **Leviton**: 1221-2, 1222-2, 1223-2, 1224-2
b. **Hubbell:** HBL1221, HBL1222, HBL1223, HBL1224

c. **Pass and Seymour:** PS20AC1, PS20AC2, PS20AC3, PS20AC4
d. **Or Equal**

2.3 GENERAL PURPOSE RECEPTACLES

A. Duplex receptacles shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEC article 406.4.

B. Damp/Wet Areas

1. Receptacles for damp/wet locations shall be weather-resistant with extra duty, in-use listed covers in accordance with NEC Article 406.8.

C. GFCIs

1. Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.

2. GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.

3. GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.

4. GFCIs shall be weather resistant-listed in accordance with NEC Article 406.8.

5. Feed-through-type GFCIs serving standard receptacles will not be permitted.

a. Leviton: G5362-WT
b. **Hubbel:** GFR5362SG
c. **Or Equal**

2.4 ENCLOSURES AND COVERS

A. Surface-mounted switches and receptacles shall be housed in FD-type weatherproof conduit fittings.

B. Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.

1. **Appleton**: FSK
2. **Crouse-Hinds**: DS185 and WLRD-1
3. **Hubbell Killark**: FZ and FC
4. **Or Equal**

C. Wet Locations

1. Receptacles in wet locations shall be provided with a hinged non-metallic Clear cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed."

2. Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.

a. **Appleton**: WCIU
b. **Crouse-Hinds**: TP74

c. **Hubbell TayMac:** Extra Duty
d. Or Equal

2.5 NAMEPLATES

A. Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.

B. ON and OFF for 3-way or 4-way switches will not be accepted.

C. Provide receptacles for special purposes with nameplates indicating their use.

D. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General.

PART 3 -- EXECUTION

3.1 GENERAL

A. Perform WORK in accordance with the requirements of the NEC.

3.2 CONNECTION

A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.

B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.

C. Receptacles indicated to be powered by uninterruptible power supplies (UPS) shall have a nameplate installed directly above the receptacle that reads:

1. (first line) “UPS-POWERED”

2. (second line) “NO TOOLS”

D. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.

3.3 GROUNDING

A. Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 26 05 26 – Grounding.

B. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.

C. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard.

3.4 FIELD TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 26 00 00 – Electrical Work, General.

B. Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

END OF SECTION

SECTION 26 05 43 - UNDERGROUND RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide underground raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. Manholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals, and Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable in order to show proposed materials and finishes.

C. As-Built Drawings

1. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

2. Show routings, burial depths, manhole and handhole locations and sizes, and where applicable, connections to drainage systems.

3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

PART 2 -- PRODUCTS

2.1 DUCTBANKS

A. Provide underground ducts constructed of Schedule 40 PVC.

B. Encase ducts in red-dyed concrete with steel reinforcing bars.

C. Provide concrete with a 3,000-psi compressive strength conforming to the requirements of Section 03 31 00 – Cast-in-Place Concrete.

D. Colorant

1. The concrete shall be dyed red throughout the ducts; surface treatment will not be accepted.

2. Provide colorant consisting of an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.

3. The costs, if any, of cleaning coloring pigment from the concrete delivery equipment and other related cleanings shall be considered as part of the WORK.

E. Ductbanks

1. Ductbanks shall contain a No. 4/0 bare stranded copper ground wire.

2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

F. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."

3. Provide tape that contains a non-ferrous metal foil conductor sandwiched in the tape for detection purposes.

4. Tape Manufacturer, or Equal: **Brady**

PART 3 -- EXECUTION

3.1 GENERAL

A. Install underground raceways between manholes and pullboxes as indicated.

B. Raceway systems shall be electrically and mechanically complete before conductors are installed.

C. Provide bends and offsets that are smooth and symmetrical, and fabricated with tools designed for this purpose.

D. Use factory elbows wherever possible.

E. To the extent possible, follow the raceway routings as indicated on the Drawings.

F. Adjust the indicated routings as necessary in order to avoid obstructions.

G. Coordination with Other Trades

1. Coordinate with other trades prior to installation of raceways.

2. The lack of coordination shall not be justification for extra compensation.

3. Perform removal and re-installation to resolve conflicts as part of the WORK.

3.2 DUCTBANKS

A. Install ductbanks in accordance with the following criteria:

1. Assemble the duct using high-impact, non-metallic spacers and saddles in order to provide conduits with vertical and horizontal separation.

2. Set the plastic spacers every 5 feet.

3. Anchor the duct array every 5 feet in order to prevent movement during the placement of concrete.

4. Lay the duct on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes or manholes.

5. Install the duct and adjust the pullbox and manhole depths such that the top of the concrete envelope is a minimum of 18 inches below grade and a minimum of 24 inches below roadways.

6. Accomplish changes in direction of the duct envelope by more than 10 degrees horizontally or vertically by using bends with a minimum radius 24 times the duct diameter.

7. Stagger duct couplings a minimum of 6 inches.

8. Provide select backfill or sand for the bottom of the trench.

9. Cleaning

a. Clean each bore of the completed ductbank by drawing through it a standard flexible mandrel, one foot long and 1/4 inch smaller than the nominal size of the duct.

b. After passing the mandrel, draw through a wire brush and swab.

10. For spare raceways that are not indicated to contain conductors, provide a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

B. Grout duct entrances smooth, and terminate ducts with flush end bells.

C. Provide watertight ductbank penetrations through walls of manholes, pullboxes, and building walls below grade.

D. Terminate concrete-encased ductbanks at building foundations.

E. Where ducts enter buildings, provide duct sealant in every duct at the building-end of the duct run to prevent water or condensation entry from the duct bank into the building. Duct sealant shall be **Polywater FST, Polywater FST-Mini,** or equal.

F. When duct enters the building on a concrete slab on grade, do not encase the duct but transition to rigid steel PVC-coated conduits on stub-ups.

G. Sealing

1. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a **Link-Seal** or equal sealing device.

2. Use the sealing device with rigid steel conduit.

3. Transition from PVC to rigid steel conduit prior to building entry.

END OF SECTION

SECTION 26 05 73 – PROTECTIVE DEVICE STUDIES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents.

B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.

C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.2 QUALIFICATIONS

A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a manufacturer who has been regularly engaged in short circuit and protective device coordination services for a period of at least 15 years.

B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of Illinois responsible for the studies.

C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.3 CONTRACTOR SUBMITTALS

A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.

B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for medium-voltage switchgear, transformers, or 480-volt distribution equipment.

C. Submit an initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.

D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.

E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

1.4 MANUFACTURERS' SERVICES

A. The medium-voltage motor control center supplier shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system coordination study.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

A. The studies shall include development of single-line and impedance diagrams of the power system.

B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.

C. The resistances and reactances of cables shall be identified in the impedance diagram.

D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.

E. The studies shall include every protective device and feeder included or modified within the WORK.

F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.

G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.2 SHORT CIRCUIT STUDY

A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

ANSI/IEEE 141	Recommended Practice for Electrical Power Distribution for Industrial Plants
ANSI/IEEE 242	Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems
ANSI/IEEE C 37.010	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI/IEEE C 37.13	Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.3 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.

C. Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.

D. Devices shall be fully rated to withstand available fault currents.

3.4 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.5 TIME/CURRENT COORDINATION CURVES

A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:

1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards

2. Each curve shall be identified, and tap and time dial settings shall be specified.

3. Provide individual curves for each feeder unless identical to others.

4. Selectivity

a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.

b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.

c. Recommendations shall be included for alternate methods that would improve selectivity.

5. time/current curves and points for cable and equipment damage.

6. circuit interrupting device operating and interrupting times

7. Indicate maximum fault values on the graph.

8. sketch of bus and breaker arrangement

9. magnetizing inrush points of transformers

10. thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve)

11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.

3.6 ARC FLASH STUDY

A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the “Arc Flash Protection Boundary” and “Personal Protective Equipment”

(PPE) levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.

B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.

C. The arc flash study shall be in accordance with the latest version of the following Standards:

1. NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces

2. IEEE 1584 IEEE guide for performing Arc Flash Hazard Calculations

3. OSHA (29 CFR PART 1910) Occupational Safety and Health Standards for General Industry

4. ANSI Z535.4 Product Safety Signs and Labels

D. The recommended values for the “Arc Flash Protection Boundary” and PPE levels, based on the arc flash study results, shall be tabulated in the study.

E. Labeling

1. The digital computer program shall provide the “Arc Flash Protection Boundary” and PPE values in a format that can be directly printed on to labels.

2. The CONTRACTOR shall provide these labels in accordance with Section 26 00 00 – Electrical Work, General.

3.7 FINAL SUMMARY REPORT

A. Summarize the results of the indicated power system studies in a final report.

B. The report shall include the following items:

1. single-line diagram

2. impedance diagram

3. tabulation of all protective devices identified on the single line diagram

4. time/current coordination curves

5. specific recommendations, if any

6. test instrumentation, condition, and connections, as applicable, for each study

7. computerized fault current calculations

8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety

9. recommendations to minimize the arc flash energy

C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.

D. Submit 2 bound copies of the report to the ENGINEER.

3.8 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.

B. Calibrate the MCPs as in accordance with the recommendations in the power system study.

C. Adjustments shall be made prior to energizing any electrical equipment.

END OF SECTION

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SECTION 26 12 16 – PANELBOARDS AND GENERAL PURPOSE DRY TYPE TRANSFORMERS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals and Section 26 00 00 - Electrical Work, General.

B. Shop Drawings

1. Transformers

a. Dimension drawings

b. Technical certification sheets

c. Drawing of conduit entry/exit locations

d. Transformer ratings, including:

1) Voltage

2) Continuous current

3) Basic impulse level for equipment over 600 volts

4) KVA

e. Descriptive bulletins

f. Product sheets

2. Panelboards

a. Breaker layout drawings with dimensions and nameplate designations

b. Component list

c. Drawings of conduit entry/exit locations

d. Assembly ratings including:

1) Short circuit rating

2) Voltage

3) Continuous current

e. Cable terminal sizes

f. Descriptive bulletins

g. Product sheets

h. Installation information

i. Seismic certification and equipment anchorage details

PART 2 -- PRODUCTS

2.1 GENERAL

A. Transformers

1. The transformers shall be dry-type, designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.

2. Transformers shall be UL-listed and bear the UL label.

B. Panelboards

1. Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Safety Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208 volt, 3 phase operation or 120/240 volt for single phase operation as indicated. Power panelboards shall be rated for 480 volts, 3 phase, 3 wire operation, unless indicated otherwise.

2. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

2.2 TRANSFORMERS

A. Energy Efficiency: Standard dry-type transformers shall meet the energy efficiency requirements of the Department of Energy Code of Federal Regulations (10 CFR PART 431), DOE 2016 Efficiency Levels.

B. Ratings

1. KVA and voltage ratings shall be as indicated.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96 - Guide for Loading Dry Type Distribution and Power Transformers

3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Up to 9 kVA	40 dB
10 to 50 kVA	45 dB
51 to 150 kVA	50 dB

C. Construction

1. Insulation Systems

a. Transformers shall be insulated as follows:

1) 2 kVA and smaller: 150 deg C insulation system based upon 80 deg C rise.

2) 3 to 15 kVA: 185 deg C insulation system based upon 115 deg C rise.

3) 15 kVA and larger: 220 deg C insulation system based upon 150 deg C rise.

b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 deg C maximum ambient.

c. Insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

2. Transformer windings shall be copper.

3. Transformers shall have four 2-1/2 percent taps, 2 above and 2 below 480 volts.

4. Transformer shall include vibration dampeners between the core and the enclosure to minimize and isolate sound transmission.

D. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal**.

2.3 PANELBOARDS

A. Ratings

1. Panelboards rated 240 VAC or less shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

2. Panelboards rated 480 VAC shall have short circuit ratings not less than 65,000 amperes RMS symmetrical or as indicated by the Protective Device Study, whichever is greater.

3. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.

B. Construction

1. Lighting and power distribution panels shall have tin-plated copper bus bars.

2. Breakers shall be one, 2, or 3 pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position.

3. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

4. Panelboards shall be rated for the intended voltage.

5. Circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. No plug-in circuit breakers will be acceptable.

6. Lighting and power distribution panels which are not part of a motor control center shall be constructed in accordance with Section 26 00 00 – Electrical Work, General. Panels shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel. Panelboard parts of metal other than copper, aluminum, or stainless steel shall be cadmium plated.

7. Panelboards shall be UL listed except for special enclosures which are not available with UL listing.

8. Panelboards shall be suitable for use as service entrance where indicated.

C. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal**

D. Surge Protection Devices (SPD)

1. Provide integral SPDs. SPDs shall conform to Section 26 43 00 – Surge Protection Devices.

2. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase.

E. Mini-Power Center

1. Provide complete with

a. main breaker

b. three-phase dry-type transformer,

c. secondary distribution loadcenter with main breaker

d. Stainless steel NEMA 4X enclosure

e. Copper windings, bolt on breakers

f. kVA rating as shown on the drawings, breakers as listed on the panel schedule

g. surge protective device

PART 3 -- EXECUTION

3.1 GENERAL

A. WORK of this Section shall be installed as indicated in Section 26 00 00 – Electrical Work, General.

END OF SECTION

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SECTION 26 43 00 - SURGE PROTECTION DEVICES (SPD)

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install surge protective devices (SPD).

B. SPDs furnished under this Section shall be ANSI/UL 1449 Type 2 integrating both surge suppression and high-frequency noise filtering suitable for use on low-voltage distribution systems.

C. The requirements of Section 26 00 00 – Electrical Work, General, apply to the WORK of this Section

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Standards:

1. ANSI/UL 1449, Fourth Edition, Safety Surge Protective Devices

2. IEEE C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits

3. IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connect to Low-Voltage (1000V and Less) AC Power Circuits

4. UL 1283, Safety Electromagnetic Interference Filters

5. NFPA 70, National Electric Code

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 26 00 00 – Electrical Work, General.

B. Shop Drawings:

1. Electrical and mechanical drawings for each type of unit, showing electrical ratings, dimensions, mounting provisions, connection details, and layout diagrams.

C. Product Data:

1. Manufacturer’s technical information, including catalog information.

2. Manufacturer's technical specifications with assembly and component ratings.

D. Certifications: Certification that SPD devices comply with standards referenced in this Section.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have at least five (5) years' experience manufacturing and servicing products substantially similar to those required and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least five (5) years each.

B. Component Supply and Compatibility:

1. Obtain all products included in this Section regardless of component manufacturer from a single SPD manufacturer.

2. SPD manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.

3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by SPD manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. SPD shall be modular, high-energy, parallel design with fast-acting transient voltage suppression using metal oxide varistors. Equipment shall provide noise attenuation with electromagnetic interference filter.

B. SPD shall be suitable for operation under the following environmental conditions:

1. Relative Humidity: Zero to 95%, non-condensing

2. Frequency: 47 to 63 Hz

3. Temperature: Zero to 149°F

4. SPD operating voltage shall be suitable for the associated SPD location(s).

5. SPD shall be suitable for internal and external mounting. SPD shall be factory-mounted and integrated into distribution equipment specified under the following Sections:

a. Section 26 00 00 – Electrical Work, General

b. Section 26 12 16 – Panelboards and General Purpose Dry Type Transformers

C. SPD shall include a surge suppression path for each mode as required for the system configuration. Each mode shall be individually fused and equipped with thermal cutouts. SPD short-circuit current rating shall be 200 kA. Protection modes shall include, to the extent applicable, the following:

1. Line-to-line

2. Line-to-neutral

3. Line-to-ground

4. Neutral-to-ground

D. SPD shall include electromagnetic interference/radio frequency interference (EMI/RFI) noise rejection filter with attenuation up to 30 dB from 10 kHz to 100 MHz.

E. SPDs and components in the operating path shall have maximum continuous operating voltage greater than 115% of nominal system operating voltage.

F. ANSI/UL 1449 minimum withstand rating shall be 20 kA per pole, and ANSI/UL 1449 voltage protection rating for SPD shall not exceed the following:

Modes	**208Y/120**	**480Y/277**
L-N,L-G, N-G	800	1200
L-L	1200	2000

G. SPD surge capacity based upon IEEE C62.41 location category shall, as a minimum, be the following:

Category	**Application**	**Per Phase**	**Per Mode**
C	Service entrance	240 kA	120 kA
B	High exposure locations (distribution equipment)	160 kA	80 kA
A	Branch locations	120 kA	60 kA

H. Provide SPD equipped with the following accessories:

1. Surge counter with display for indicating the number of surges detected.

2. LED indicators for monitoring device status.

3. Audible alarm and silence switch for indicating an inoperative condition.

4. Dry contacts, “form C”, for remote annunciation of unit status.

I. Source Quality Control: Perform manufacturer’s standard factory tests on equipment. Tests shall be in accordance with ANSI/UL 1449.

J. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal.**

PART 3 -- EXECUTION

3.1 GENERAL

A. Install SPD in accordance with equipment manufacturer’s written recommendations and instructions and the Contract Documents.

B. Where an SPD cannot be installed integral with the equipment to which it is connected, conductor length between suppressor and connection point shall be as short and as straight as possible.

END OF SECTION

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SECTION 26 50 00 - LIGHTING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide luminaires and accessories, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

NFPA 70	National Electrical Code
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
International Building Code (IBC)	Earthquake Requirements
UL-595	Standard for Safety Marine-Type Electric Lighting Fixtures
UL-844	Standard for Safety Electric Lighting Fixtures for Use in Hazardous (Classified Locations)
UL-924	Standard for Safety Emergency Lighting and Power Equipment
ANSI C82.1	Specifications for Fluorescent Lamp Ballasts
ANSI C84.4	Specifications for High-Intensity-Discharge Lamp Ballasts (Multiple SupplyType)

Standards of the Certified Ballast Manufacturer’s Association

1.3 CONTRACTOR SUBMITTALS

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

B. Furnish the following information:

1. Luminaires

    a. catalog data sheets and photos

    b. luminaire finish and metal gauge

    c. lens material, pattern, and thickness

        1) candlepower distribution curves in 2 or more planes

    d. candlepower chart, 0 to 90 degrees

e. lumen output chart

f. average maximum brightness data in foot-lamberts

g. coefficients of utilization for zonal cavity calculations

h. mounting or suspension details

i. heat exchange and air handling data

2. LEDs

a. voltages

b. colors

c. approximate life (in hours)

d. approximate initial lumens

e. lumen maintenance curve

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. General

1. Provide luminaries as indicated in the Luminaire Schedule on the Drawings.

B. Provide a feed-through type or separate junction box.

C. Provide minimum 18 AWG wire leads.

D. Provide components that are accessible and replaceable without removing the luminaire from the ceiling.

PART 3 -- EXECUTION

3.1 LUMINAIRES

A. General

1. Install in accordance with the manufacturer’s recommendations.

2. Provide necessary hangers, pendants, canopies, and other accessories.

3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to the structure as required to safely mount the luminaire.

4. Install the luminaire plumb and level.

5. The mounting heights indicated for wall-mounted or pendant-mounted luminaires are from the bottom of the luminaire to finished floor or finished grade, whichever is applicable.

6. Install each luminaire outlet box with a galvanized stud.

B. Unfinished Areas

1. Locate the luminaires to avoid conflicts with other building systems and blockage of the luminaire light output.

2. Luminaire Suspension

a. Provide 1/4- inch threaded stainless-steel hanger rods.

b. Scissor-type hangers will not be accepted.

3. For attachments to steel beams, provide flanged beam clips and straight or angled hangers.

3.2 CLEAN-UP

A. Remove labels and other markings, except the UL listing mark.

B. Wipe the luminaires inside and out in order to remove construction dust.

C. Clean the luminaire plastic lenses with an antistatic cleaner only.

D. Touch up painted surfaces of the luminaires and the poles with matching paint provided by the manufacturer.

E. Replace defective luminaires and/or drivers at the Date of Substantial Completion.

END OF SECTION

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SECTION 31 10 00 - SITE PREPARATION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. In its initial move onto the Site, the CONTRACTOR shall protect existing fences, houses and associated improvements, streets, and utilities downslope of construction areas from damage due to boulders, trees, or other objects dislodged during the construction process and clear, grub, strip; and regrade certain areas, in accordance with the Contract Documents.

1.2 SITE INSPECTION

A. Prior to moving onto the Site, the CONTRACTOR shall inspect the Site conditions and review maps of the Site and facilities delineating the OWNER's property and right-of-way lines.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 PRIMARY PLANT SITE ACCESS

A. The CONTRACTOR shall develop any necessary access to the Site, including access barriers to prohibit entry of unauthorized persons.

B. **Utility Interference:** Where existing utilities interfere with the WORK, notify the utility owner and the ENGINEER before proceeding in accordance with the General Conditions.

3.2 CLEARING, GRUBBING, AND STRIPPING

A. Construction areas shall be cleared of grass and weeds to at least a depth of 6-inches and cleared of structures, pavement, sidewalks, concrete or masonry debris, trees, logs, upturned stumps, loose boulders, and any other objectionable material of any kind which would interfere with the performance or completion of the WORK, create a hazard to safety, or impair the subsequent usefulness of the WORK, or obstruct its operation. Loose boulders within 10-feet of the top of cut lines shall be incorporated in landscaping or removed from the Site. Trees and other natural vegetation outside the actual lines of construction shall be protected from damage during construction.

B. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove stumps, roots, buried logs, and other objectionable material. Septic tanks, drain fields, and connection lines and any other underground structures, debris or waste shall be removed if found on the Site. Objectionable material from the clearing and grubbing process shall be removed from the Site and wasted in approved safe locations.

C. The entire area to be affected by construction shall be stripped to a depth of 6 inches below the existing ground contours. The stripped materials shall be stockpiled and incorporated into landscaped areas or other non-structural embankments.

D. Unless otherwise indicated, native trees larger than 3-inches in diameter at the base shall not be removed without the ENGINEER's approval. The removal of any trees, shrubs, fences, or other improvements outside of rights-of-way, if necessary for the CONTRACTOR's choice of means and methods, shall be arranged with the owner of the property, and shall be removed and replaced, as part of the WORK.

END OF SECTION

SECTION 31 22 60 – EXCAVATION SUPPORT SYSTEM

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The work in this Section includes design and installation of initial ground support systems for structures and pipelines exclusive of marine pipe and structure excavations SITE INSPECTION

B. The initial ground support system is the support installed prior to or concurrent with excavation and modification of the valve vault, Shorewell #3 connection, and pipe at depths greater than 5 feet, to maintain stability of an excavation to be occupied by workers, until the excavation is closed.

1.2 INITIAL GROUND SUPPORT SYSTEM DESIGN

A. The CONTRACTOR shall be solely responsible for design of initial ground support systems. The design shall be performed by a registered Structural engineer licensed in the State of Illinois, experienced in the design of initial ground support systems for similar applications.

B. The design shall also be as per requirements of state, federal, OSHA, marine and other applicable requirements for land and offshore underwater excavations.

C. The design shall provide for, as a minimum, ground loads, groundwater pressures, surcharge loads, and construction loads.

D. Design lateral pressures provided in bore logs shall be considered minimum design loads. The CONTRACTOR shall verify that they are adequate for the expected ground conditions, and are appropriate for the type of support system proposed and for the means and methods of construction.

E. Ground support systems shall maintain the safety of personnel, prevent damage to adjacent property, and maintain the inherent strength and stability of ground surrounding the excavation. Initial ground support systems shall prevent ground loading on the new Work until after design strength has been reached.

F. Design of the initial ground support system shall consider:

1. Ground conditions and lateral earth pressure indicated in Appendix A,

2. Methods for control of water,

3. Maintaining soil stability at the bottom of the excavation;

4. Deformation, as well as stability, of the support system under load;

5. Proximity of existing underground and above-ground structures;

6. Effects on adjacent structures of vibration from driving and pulling sheeting and piling;

7. Method and rate of advance of excavation;

8. All loading conditions, including loading due to delay in adding support members, removal of support members, and dynamic loading;

9. Sheet pile penetration by pipes;

10. Placement of permanent structures;

11. Design drawings shall be signed and sealed by the licensed Structural Engineer registered in the State of Illinois.

G. The CONTRACTOR shall verify dimensions and take measurements as required to properly fabricate and erect the support system.

H. The CONTRACTOR shall be solely responsible for obtaining any information needed for the design that is not provided in the Contract Documents.

1.3 SUBMITTALS

A. These submittal requirements may be coordinated with submittal requirements ofSection 01 33 00 – Contractor Submittals.

B. Submit drawings and computations describing initial ground support systems for the valve vault, Shorewell #3, and pipe at depths greater than 5 feet that are signed and stamped by the Contractor's structural engineer licensed in State of Illinois.

C. Submittal shall include:

1. Design loading conditions;

2. Member sizes and thicknesses, and strength properties of materials to be used;

3. Codes and reference standards used as a basis for design;

4. Correctly dimensioned layout of support system including location of members (such as beams, columns, piles, walers, struts, sheeting and other supports);

5. Connection details;

6. Sequence of erection;

7. Maximum allowable spacing between bracing points on compression members to maintain stability and alignment;

8. Requirements or limits on pre-loading braces;

9. Location, dimensions, and means of ensuring stability at openings;

10. Description of method of installation for initial support members installed in advance of excavation, and method of correcting support system defects exposed by subsequent excavation;

11. Description of quality control methods for initial support members cast in place in advance of excavation;

12. Overstress of members shall not be allowed;

13. Location of instrumentation in accordance with Section 02 22 13 requirements.

14. Design drawings shall be signed and sealed by the licensed Structural Engineer registered in the State of Illinois.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

A. Construct initial ground support systems to line, grade, dimensions, and tolerances shown on the CONTRACTOR's design drawings.

B. Install and remove support members following the sequence of operations shown on the CONTRACTOR's shop drawings.

C. Develop and maintain firm and uniform bearing of the support system against the ground, such as by expanding the support system tightly against the ground, or by filling the void space between a non-expanding support system and the ground by contact grouting.

D. Periodically examine initial ground support systems in place to identify loosening or unstable ground, or loss of ground through the support system; and excessive deformation, overstress, or weakening of the support system.

E. Promptly reset, repair, or replace initial ground support system elements that settle, become misaligned, were improperly installed, or become damaged during construction.

3.2 REMOVAL OF INITIAL GROUND SUPPORT SYSTEMS

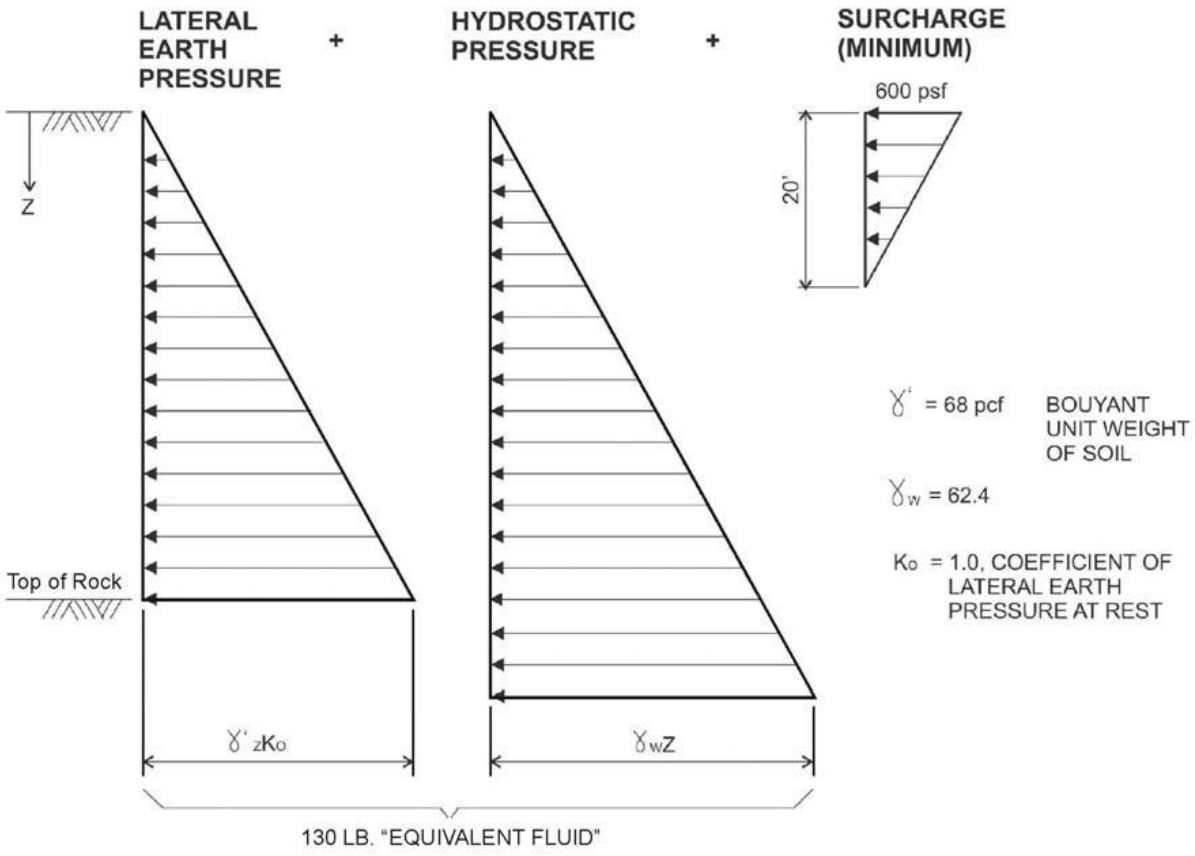
A. The CONTRACTOR shall repair any settlement or damage to the Work or adjacent property resulting from removal of initial ground support systems.

B. Support systems that extend below the bottom of the excavation shall not be removed without prior approval of the Engineer.

C. Support systems that, in the sole opinion of the CONTRACTOR, that cannot be removed without causing damage, shall be left in place, at no additional cost to the OWNER.

D. Support systems shall be removed to a depth of at least 6 feet below ground surface so as not to interfere with future near-surface development, unless otherwise approved by the Engineer.

APPENDIX A



LATERAL PRESSURE ON PERMANENT WALLS AND INITIAL GROUND SUPPORT SYSTEMS

NOTES:

1. FOR CYLINDRICAL STRUCTURES, THE ABOVE ARE APPLIED RADIALLY TO COMPUTE RING LOADS.
2. DISTORTION STRESSES ARE TO BE SUPERIMPOSED, AS OUTLINE IN THE IN THE TEXT.
3. FOR PERMANENT STRUCTURES, WATER LEVEL IS ASSUMED AT GROUND SURFACE.
4. CIRCULAR COFFERDAMS FOR TEMPORARY EXCAVATION SUPPORT MAY BE DESIGNED FOR ABOVE CONDITIONS, PROVIDING METHODS RECOMMENDED BY DEERE, PECK ET AL (1969) ARE FOLLOWED.

END OF SECTION

SECTION 31 23 19 - DEWATERING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall dewater trench and structure excavations, in accordance with the Contract Documents. The CONTRACTOR shall secure all necessary permits to complete the requirements of this Section of the Specifications.

1.2 CONTRACTOR SUBMITTALS

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

B. Prior to commencement of excavation, the CONTRACTOR shall submit a detailed plan and operation schedule for dewatering of excavations. The detailed plan shall include mitigation measures to prevent settlement of nearby structures and a contingency plan for restoring nearby structures if settlement is observed as a result of the CONTRACTOR’s dewatering operations. The CONTRACTOR may be required to demonstrate the system proposed and to verify that adequate equipment, personnel, and materials are provided to dewater the excavations at all locations and times. The CONTRACTOR's dewatering plan is subject to review by the ENGINEER.

1.3 QUALITY CONTROL

A. It shall be the sole responsibility of the CONTRACTOR to control the rate and effect of the dewatering in such a manner as to avoid all objectionable settlement and subsidence.

B. All dewatering operations shall be adequate to assure the integrity of the finished project and shall be the responsibility of the CONTRACTOR.

C. All structures or facilities that are located within the radius of influence of the CONTRACTOR’s dewatering operation shall have reference points established and observed at frequent intervals to detect any settlement which may develop. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with the CONTRACTOR. The CONTRACTOR shall survey, record and report the reference points on a daily basis, and submit the written log to the ENGINEER at the completion of construction. The ENGINEER shall be immediately notified should any sign of settlement is observed. The cost of repairing any damage to adjacent structures and restoration of facilities shall be the responsibility of the CONTRACTOR.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. Dewatering, where required, may include the use of well points, sump pumps, temporary pipelines for water disposal, rock or gravel placement, and other means. Standby pumping equipment shall be maintained on the Site.

PART 3 -- EXECUTION

3.1 GENERAL REQUIREMENTS

A. The CONTRACTOR shall provide all equipment necessary for dewatering. It shall have on hand, at all times, sufficient pumping equipment and machinery in good working condition and shall have available, at all times, competent workmen for the operation of the pumping equipment. Adequate standby equipment shall be kept available at all times to insure efficient dewatering and maintenance of dewatering operation during power failure.

B. Dewatering for structures and pipelines shall commence when groundwater is first encountered, and shall be continuous until such times as water can be allowed to rise in accordance with the provisions of this Section or other requirements.

C. At all times, site grading shall promote drainage. Surface runoff shall be diverted from excavations. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and be pumped or drained by gravity from the excavation to maintain a bottom free from standing water.

D. Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation.

E. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, the affected areas shall be excavated and replaced with drain rock.

F. The CONTRACTOR shall maintain the water level below the bottom of excavation in all work areas where groundwater occurs during excavation construction, backfilling, and up to acceptance.

G. Flotation shall be prevented by the CONTRACTOR by maintaining a positive and continuous removal of water. The CONTRACTOR shall be fully responsible and liable for all damages which may result from failure to adequately keep excavations dewatered.

H. If well points or wells are used, they shall be adequately spaced to provide the necessary dewatering and shall be sandpacked and/or other means used to prevent pumping of fine sands or silts from the subsurface. A continual check by the CONTRACTOR shall be maintained to ensure that the subsurface soil is not being removed by the dewatering operation.

I. The CONTRACTOR shall dispose of water from the WORK in a suitable manner without damage to adjacent property. CONTRACTOR shall be responsible for obtaining any permits that may be necessary to dispose of water. No water shall be drained into work built or under construction without prior consent of the ENGINEER. Water shall be filtered using an approved method to remove sand and fine-sized soil particles before disposal into any drainage system.

J. The release of groundwater to its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill and prevent flotation or movement of structures, pipelines, and sewers.

K. Dewatering of trenches and other excavations shall be considered as incidental to the construction of the WORK and all costs thereof shall be included in the various contract prices in the Bid Forms, unless a separate bid item has been established for dewatering.

END OF SECTION

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SECTION 31 30 00 - EARTHWORK

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall perform earthwork as indicated and required for construction of the WORK, complete and in place, in accordance with the Contract Documents.

B. This Section applies to earthwork for the landside portions of the Work. See Section 35 23 21 – Excavation and Backfill for Marine Construction for earthwork associated with marine construction.

1.2 CONTRACTOR SUBMITTALS

A. CONTRACTOR's Detailed Plan

1. The CONTRACTOR, prior to beginning any trench or structure excavation 5 feet deep or deeper, shall submit an excavation plan in accordance with Section 31 22 60 – Excavation Support.

B. Samples

1. The CONTRACTOR shall submit samples of materials proposed for the WORK in conformance with the requirements of Section 01 33 00 – Contractor Submittals.

2. Sample sizes shall be as determined by the testing laboratory.

PART 2 -- PRODUCTS

2.1 FILL AND BACKFILL MATERIAL REQUIREMENTS

A. General

1. Fill, backfill, and embankment materials shall be selected or shall be processed and clean fine earth, rock, gravel, or sand, free from grass, roots, brush, other vegetation and organic matter.

2. Fill and backfill materials that are to be placed within 6 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

B. Suitable Materials

1. Materials not defined below as unsuitable will be considered as suitable materials and may be used in fills, backfilling, and embankment construction, subject to the indicated requirements.

2. If acceptable to the ENGINEER, some of the material listed as unsuitable may be used when thoroughly mixed with suitable material to form a stable composite.

3. Mixing or blending of materials to obtain a suitable composite is the CONTRACTOR's option but is subject to the approval of the ENGINEER.

4. The CONTRACTOR shall submit certification to the ENGINEER that the chloride concentration in imported materials within the pipe zone does not exceed 100 ppm, when tested in accordance with the requirements of AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

5. Suitable materials may be obtained from on-Site excavations, may be processed on-Site materials, or may be imported.

6. If imported materials are required by this Section or are required in order to meet the quantity requirements of the WORK, the CONTRACTOR shall provide the imported materials as part of the WORK.

C. The following types of materials are defined:

1. Fine Aggregate (IDOT FA-6)

2. Coarse Aggregate (IDOT CA-6)

2.2 MATERIALS TESTING

A. Samples

1. Soils testing of samples submitted by the CONTRACTOR will be performed by a testing laboratory of the OWNER's choice and at the CONTRACTOR’s expense.

2. The ENGINEER may direct the CONTRACTOR to supply samples for testing of any material used in the WORK.

B. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils.

C. Determination of sand equivalent value will be performed using ASTM D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System

1. References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487.

2. The CONTRACTOR shall be bound by applicable provisions of ASTM D 2487 in the interpretation of soil classifications.

E. Testing for chloride shall be performed in accordance with AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

2.3 IDENTIFICATION TAPE

A. Unless otherwise indicated, identification tape shall be placed above buried pipelines that are not comprised of magnetic components at least in part.

B. Identification tape shall be 6-inches wide, yellow in color, composed of polyethylene, and provided with an integral metallic wire.

C. Tape shall be labeled with CAUTION – BURIED UTILITIES.

2.4 SOIL STERILANT

A. Soil sterilant or chemical weed control agent shall be a commercial product manufactured specifically to sterilize the subgrade soil against the growth of weeds, plants, or any type of vegetation.

PART 3 -- EXECUTION

3.1 EXCAVATION AND BACKFILLING - GENERAL

A. General

1. Except when specifically provided to the contrary, excavation shall include the removal of materials, including obstructions, that would interfere with the proper execution and completion of the WORK.

2. The removal of such materials shall conform to the lines and grades indicated or ordered.

3. Unless otherwise indicated, the entire Site shall be stripped of vegetation and debris and shall be grubbed, and such material shall be removed from the Site prior to performing any excavation or placing any fill.

4. The CONTRACTOR shall furnish, place, and maintain supports and shoring that may be required for the sides of excavations.

5. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable state safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).

6. The CONTRACTOR shall provide quantity surveys where so required to verify quantities for Unit Price Contracts.

7. Surveys shall be performed prior to beginning WORK and upon completion by a surveyor licensed in the state where the Site is located.

B. Removal and Exclusion of Water

1. The CONTRACTOR shall remove and exclude water, including stormwater, groundwater, irrigation water, and wastewater, from excavations.

2. Dewatering wells, wellpoints, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation WORK begins at each location.

   Water shall be removed and excluded until backfilling is complete and field soils testing has been completed.

3.2 OVER-EXCAVATION

A. Indicated

1. Where areas are indicated to be over-excavated, excavation shall be to the depth indicated, and backfill shall be installed to the grade indicated.

B. Not Indicated

1. When ordered to over-excavate areas deeper and/or wider than required by the Contract Documents, the CONTRACTOR shall over-excavate to the dimensions ordered and backfill to the indicated grade.

C. Neither Indicated nor Ordered

1. Any over-excavation carried below the grade that is neither ordered or nor indicated shall be backfilled and compacted to the required grade with the indicated material as part of the WORK

3.3 EXCAVATION IN LAWN AREAS

A. Where excavation occurs in lawn areas, the sod shall be carefully removed, dampened, and stockpiled in order to preserve it for replacement.

B. Excavated material may be placed on the lawn, provided that a drop cloth or other suitable method is employed to protect the lawn from damage, but the lawn shall not remain covered for more than 72 hours.

C. Immediately after completion of backfilling the sod shall be replaced and lightly rolled in a manner as to restore the lawn as near as possible to its original condition.

D. The CONTRACTOR shall provide new sod if the stockpiled sod has not been replaced within 72 hours.

3.4 EXCAVATION IN VICINITY OF TREES

A. Except where trees are indicated to be removed, trees shall be protected from injury during construction operations.

B. No tree roots larger than 2 inches in diameter shall be cut without the express permission of the ENGINEER.

C. Trees shall be supported during excavation by any means previously reviewed and accepted by the ENGINEER.

3.5 ROCK EXCAVATION

A. Rock excavation shall include removal and disposal of the following items:

1. boulders measuring 1/3 of a cubic yard or more in volume;

2. rock material in ledges, bedding deposits, and un-stratified masses that cannot be removed using conventional equipment as defined herein and which require systematic drilling and blasting for removal;

3. concrete or masonry structures that have been abandoned; and,

4. conglomerate deposits that are so firmly cemented that they possess the characteristics of solid rock and cannot be removed using conventional equipment as herein defined and require systematic drilling and blasting for removal.

B. Scope and Payment

1. Rock excavation shall be performed by the CONTRACTOR, provided that if the quantity of rock excavation is affected by any change in the scope of the WORK an appropriate adjustment of the Contract Price will be made under a separate Bid Item if such Bid Item has been established.

2. Otherwise, payment will be made in accordance with a negotiated price.

C. Explosives and Blasting: Blasting will not be permitted.

3.6 DISPOSAL OF EXCESS EXCAVATED MATERIAL

A. Unless otherwise indicated, excess excavated material shall be the property of the CONTRACTOR.

B. The CONTRACTOR shall be responsible for the removal and disposal of excess excavated material.

C. Material shall be disposed of at an approved on-Site disposal area or off-Site at a location arranged by the CONTRACTOR in accordance with laws and regulations regarding the disposal of such material.

3.7 BACKFILL

A. General

1. Backfill shall not be dropped directly upon any structure or pipe.

2. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed.

3. Backfill around water-retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed.

B. Except for drainrock materials being placed in over-excavated areas or trenches, backfill shall be placed after water is removed from the excavation and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

C. Pre-Placement Conditions

1. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have any loose, sloughing, or caving soil and rock materials removed.

2. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

D. Soil Sterilant

1. Apply soil sterilant or a chemical weed control agent under roads and as indicated, in strict compliance with the manufacturer's dosage and application instructions and with applicable laws, ordinances, and regulations governing the use of such chemicals.

E. Layering

1. Backfill materials shall be placed and spread evenly in layers, maximum lift of 6 inches.

2. When compaction is achieved using mechanical equipment, the layers shall be evenly spread such that when compacted each layer shall not exceed 6 inches in thickness.

F. During spreading, each layer shall be thoroughly mixed as necessary in order to promote uniformity of material in each layer.

G. Moisture Content

1. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

2. Where the backfill material moisture content is too high to permit the indicated degree of compaction, the material shall be dried until the moisture content is satisfactory.

3.8 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION AND BACKFILL

A. Excavation Beneath Structures and Embankments

1. Except where indicated otherwise for a particular structure or where ordered by the ENGINEER, excavation shall be carried to an elevation 6 inches below the bottom of the footing or slab and brought back to grade with compacted materials acceptable for placement beneath structures.

2. The area where a fill or embankment is to be constructed shall be cleared of vegetation, roots, and foreign material.

3. Where indicated or ordered, areas beneath structures or fills shall be over-excavated.

4. The subgrade areas beneath embankments shall be excavated to remove not less than the top 6 inches of native material and where such subgrade is sloped, the native material shall be benched.

5. When such over-excavation is indicated, both the over-excavation and the subsequent backfill to the required grade shall be performed by the CONTRACTOR.

6. After the required excavation or over-excavation for fills and embankments has been completed, the exposed surface shall be scarified to a depth of 6 inches,

brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

B. Excavation Beneath Paved Areas

1. Excavation under areas to be paved shall extend to the bottom of the aggregate base or subbase, if such base is called for; otherwise it shall extend to the paving thickness.

2. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

3. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement.

4. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

C. Notification of ENGINEER

1. The CONTRACTOR shall notify the ENGINEER at least 3 Days in advance of completion of any structure or roadway excavation and shall allow the ENGINEER a review period of at least one day before the exposed foundation is scarified and compacted or is covered with backfill or with any construction materials.

D. Compaction of Fill, Backfill, and Embankment Materials

1. Each layer of backfill materials as defined herein, where the material is graded such that 10 percent or more passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density.

2. Equipment that is consistently capable of achieving the required degree of compaction shall be used, and each layer shall be compacted over its entire area while the material is at the required moisture content.

3. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of obtaining the required density in 2 passes.

4. Backfill beneath structures such as metering vaults shall be CA-6.

E. Flooding, ponding, and jetting shall not be used for fill on roofs, backfill around structures, backfill around reservoir walls, for final backfill materials, or aggregate base materials.

F. Heavy Equipment

1. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the vertical depth of the fill above undisturbed soil at that time.

2. Hand-operated power compaction equipment shall be used where the use of heavier equipment is impractical or restricted due to weight limitations.

G. Layering

1. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers.

2. Each layer shall be moistened and aerated as necessary.

3. Unless otherwise approved by the ENGINEER, no layer shall exceed 6 inches of compacted thickness.

4. The embankment and fill shall be compacted in conformance with Paragraph K, below.

H. Embankments and Fills

1. When an embankment or fill is to be constructed and compacted against hillsides or fill slopes steeper than 4:1, the slopes of the hillsides or fills shall be horizontally benched in order to key the embankment or fill to the underlying ground.

2. A minimum of 12 inches perpendicular to the slope of the hillside or fill shall be removed and re-compacted as the embankment or fill is brought up in layers.

3. Material thus cut shall be re-compacted along with the new material.

4. Hillside or fill slopes 4:1 or flatter shall be prepared in accordance with Paragraph A, above.

I. Compaction Requirements

1. The following compaction requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft^3) (2,700 kN-m/m^3) where the material is graded such that 10 percent or more passes a No. 4 sieve and in accordance with ASTM D 4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density, where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve:

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Embankments and fills not identified otherwise	90	55
Embankments and fills beneath paved areas or structures	95	70
Backfill beneath structures and hydraulic structures	95	70

Backfill on reservoir of structure roof	90	55
Topsoil	80	NA
Aggregate base or subbase	95	NA

3.9 PIPELINE AND UTILITY TRENCH EXCAVATION AND BACKFILL

A. Exploratory Excavations

1. The CONTRACTOR shall excavate and expose buried points of connection to existing utilities as indicated.

2. Excavation shall be performed prior to the preparation of Shop Drawings for connections and before the fabrication of the pipe

3. The data obtained from exploratory excavations shall be used in preparing the Shop Drawings.

4. Data, including dates, locations excavated, and dimensioned sketches, shall be submitted to the ENGINEER within one week of excavation.

5. Damage to utilities from excavation activities shall be repaired by the CONTRACTOR in accordance with the General Conditions.

B. General

1. Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with minimum widths as indicated.

C. Trench Bottom

1. Except where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe.

2. Excavations for pipe bells and welding shall be made as required.

3. Where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe bedding.

D. Open Trenches

1. The maximum amount of open trench permitted in any one location shall be 500 feet or the length necessary to accommodate the amount of pipe installed in a single Day, whichever is greater.

2. Trenches shall be fully backfilled at the end of each Day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting vehicular traffic in those locations where it is impractical to backfill at the end of each Day.

3. These requirements for backfilling or use of steel plate will be waived in cases where the trench is located further than 100 feet from any traveled roadway or occupied structure; in such cases, however, barricades and warning lights meeting appropriate safety requirements shall be provided and maintained.

E. Embankments, Fills and Structural Backfills

1. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

2. Upon completion of the embankment or structural backfill, a trench conforming to the appropriate detail may be excavated and the pipe may be installed.

F. Trench Shield

1. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield such that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls and causing sloughing or caving of the trench walls.

2. If the trench walls cave or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally.

4. The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

G. Placing and Spreading Of Backfill Materials

1. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of achieving the required density in 2 passes and that is acceptable to the ENGINEER.

2. Where such materials are used for pipe zone backfill, vibratory compaction shall be used at vertical intervals of the lesser of:

   a. one-half the diameter of the pipe; or

   b. 24 inches, measured in the uncompacted state.

3. Each layer of backfill material with greater than 10 percent passing the No. 4 sieve shall be compacted using mechanical compactors suitable for the WORK.

4. The material shall be placed and compacted under the haunch of the pipe and up each side evenly so as not to move the pipe during the placement of the backfill.

5. The material shall be placed in lifts that will not exceed 6 inches when compacted to the required density using Method 1 in accordance with IDOT Standard

Specifications, Article 550.07. The contractor shall be responsible for any settlement within he first year.

H. Mechanical Compaction

1. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand-operated vibratory compactors and rollers that do not damage the pipe.

2. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

I. Pipe And Utility Trench Backfill

1. Pipe Zone Backfill

a. Definitions

1) The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane below the bottom surface of the pipe and a plane at a point above the top surface of the pipe as indicated.

2) The bedding is defined as that portion of pipe zone backfill material between the trench subgrade and the bottom of the pipe.

3) The embedment is defined as that portion of the pipe zone backfill material between the bedding and a level line as indicated.

b. Final Trim

1) After compacting the bedding, the CONTRACTOR shall perform a final trim using a stringline for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe.

2) Excavation for pipe bells and welding shall be made as required.

c. The pipe zone shall be backfilled with IDOT CA-6 or IDOT FA-6.

d. Pipe zone backfill materials shall be manually spread evenly around the pipe, maintaining the same height on both sides of the pipe such that when compacted the pipe zone backfill will provide uniform bearing and side support.

e. The CONTRACTOR shall exercise care in order to prevent damage to the pipeline coating, cathodic bonds, and the pipe itself during the installation and backfill operations.

2. Trench Zone Backfil

a. After the pipe zone backfill has been placed, backfilling of the trench zone may proceed.

b. The trench zone is defined as that portion of the vertical trench cross-section lying as indicated between a plane above the top surface of the pipe and a plane at a point 18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the roadway subgrade.

c. The trench zone shall be backfilled with IDOT CA-6 or IDOT FA-6 if under pavement or within two (2) feet of the edge of the pavement. For all other locations, the trench zone shall be backfilled with IDOT CA-6, IDOT FA-6, or native material approved by the ENGINEER

3. Final Backfill

a. Final backfill is defined as backfill in the trench cross-sectional area within 18 inches of finished grade, or if the trench is under pavement, backfill within 18 inches of the roadway subgrade.

b. The final backfill shall be backfilled IDOT CA-6 or IDOT FA-6 if under pavement or within two (2) feet of the edge of the pavement. For all other locations, final back fill shall be stockpiled topsoil material which has been obtained at the Site by removing soil to a depth not exceeding 2 feet. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris

J. Identification Tape

1. Install identification tape as indicated.

2. Terminate the tape in a precast concrete box either adjacent to or part of the valve box, manhole, vault, or other structure into which the non-metallic pipe enters or at the end of the non-metallic pipeline.

3. The termination box shall be covered with a cast iron lid.

4. The box shall be located at grade in paved areas or 6 inches above grade in unpaved areas.

K. Trench Shield

1. If a moveable trench shield is used during backfill operations, the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer.

2. The CONTRACTOR shall not displace the pipe or backfill while the shield is being moved.

L. Compaction Requirements

1. The following compaction test requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft^3) (2,700 kN-m/m^3) where the material is graded such that 10 percent or more passes a No. 4 sieve, and in accordance with ASTM D 4253 - Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve.

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Pipe embedment backfill for flexible pipe.	90	70
Pipe bedding and over-excavated zones under bedding for flexible pipe, including trench plugs.	90	70
Pipe embedment backfill for steel yard piping	---	70
Pipe zone backfill portion above embedment for flexible pipe	90	40
Pipe embedment backfill for rigid pipe	90	55
Pipe zone backfill portion above embedment for rigid pipe.	85	40
Pipe bedding and over-excavated zones under bedding for rigid pipe.	95	55
Final backfill, beneath paved areas or structures.	95	70
Final backfill, not beneath paved areas or structures.	85	40
Trench zone backfill, beneath paved areas and structures, including trench plugs.	90	55
Trench zone backfill, not beneath paved areas or structures, including trench plugs.	85	40

3.10 FIELD TESTING

A. General:

1. Field soils testing will be performed by a testing laboratory of the OWNER's choice at the OWNER's expense, except as indicated below.

B. Density

1. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557.

2. Where cohesionless, free draining soil material is required to be compacted to a percentage of relative density, the calculation of relative density will be determined in accordance with ASTM D 4253 and D 4254.

3. Field density in-place tests will be performed in accordance with ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method, ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place By Nuclear Methods (Shallow Depth), or by such other means acceptable to the ENGINEER.

C. Remediation

1. In case the test of the fill or backfill shows non-compliance with the required density, the CONTRACTOR shall accomplish such remedy as may be required to ensure compliance.

2. Subsequent testing to show compliance shall be by a testing laboratory selected by the OWNER and paid by the CONTRACTOR.

D. CONTRACTOR's Responsibilities

1. The CONTRACTOR shall provide test trenches and excavations, including excavation, trench support and groundwater removal for the OWNER's field soils testing operations.

2. The trenches and excavations shall be provided at the locations and to the depths as required by the OWNER.

3. Lawn areas destroyed by test trenching and excavation shall be regraded and landscaped with hydroseeding.

END OF SECTION

SECTION 31 34 19 - GEOTEXTILES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide geotextiles, complete and in place, in accordance with the Contract Documents.

B. Definitions: The following definitions apply to the WORK of this Section:

1. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

2. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile provided.

3. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile provided.

4. Nondestructive Sample: Sample representative of finished geotextile, prepared for testing without destruction of geotextile.

5. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

6. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D 4884.

7. Woven geotextile: A geotextile fabric composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern.

8. Nonwoven geotextile: A geotextile fabric composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The following standards are referenced in this Section:

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D 4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile

ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D 4884	Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Sewn Geotextiles
ASTM D 4886	Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method)

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings

1. Manufacturer material specifications and product literature.

2. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.

3. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

C. Samples

1. Geotextile: One-piece, minimum 18-inches long, taken across full width of roll of each type and weight of geotextile. Label each with brand name and furnish documentation of lot and roll number from which each sample was obtained.

2. Field Sewn Seam: 5-foot length of seam, 12-inches wide with seam along center, for each type and weight of geotextile.

3. Securing Pin and Washer: 1 each.

D. Certifications

1. Certification from geotextile manufacturer that products satisfy the indicated requirements.

2. Field seam efficiency test results.

PART 2 -- PRODUCTS

2.1 WOVEN GEOTEXTILE

A. Woven geotextile shall be composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. Sheet Edges: Selvaged or finished to prevent outer material from separating from sheet.

D. Unseamed Sheet Width: Minimum 6feet.

E. Nominal Weight per Square Yard: 6.

F. Physical Properties: Conform to requirements below.

PHYSICAL PROPERTY REQUIREMENTS FOR WOVEN GEOTEXTILE		
Property	Requirement	Test Method
Apparent Opening Size (AOS)	No. 10 to No. 100 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	0.02 to 3.34 $sec.^{-1}$, MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	10 to 150 gpm/sq ft, MinARV	
Wide Width Strip Tensile Strength	60 to 1,500 lb/in.-width, MinARV	ASTM D 4595
Wide Width Strip Elongation	14 to 60 percent, MaxARV	
Trapezoidal Tear Strength	30 to 200 lb, MinARV	ASTM D 4533
Puncture Strength	50 to 250 lb, MinARV	ASTM D 4833
Abrasion Resistance	5 to 25 percent loss, 250 cycles, MaxARV	ASTM D 4886
Ultraviolet Radiation Resistance	70 to 90 percent strength retention, MinARV after 500 hours	ASTM D 4355

2.2 NONWOVEN GEOTEXTILE

A. Nonwoven geotextile shall be composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester, polypropylene, or polyethylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. Geotextile Edges: Selvaged or finished to prevent outer material from separating from sheet.

D. Unseamed Sheet Width: Minimum 6-feet.

E. Nominal Weight per Square Yard: 12 ounces.

F. Physical Properties: Conform to requirements below.

PHYSICAL PROPERTY REQUIREMENTS FOR NONWOVEN GEOTEXTILE		
Property	Requirement	Test Method
Apparent Opening Size (AOS)	No. 100 to No. 140 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	1.2 $sec.^{-1}$, MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	90 gpm/sq ft, MinARV	
Wide Width Strip Tensile Strength	300 MinARV	ASTM D 4595
Wide Width Strip Elongation	70 percent, MaxARV	ASTM D 4595
Trapezoidal Tear Strength	120 lb, MinARV	ASTM D 4533
Puncture Strength	130 lb, MinARV	ASTM D 4833
Ultraviolet Radiation Resistance	90 percent strength retention, MinARV after 500 hours	ASTM D 4355

2.3 SEWING THREAD

A. Sewing thread shall be polypropylene, polyester, or Kevlar thread with durability equal to or greater than durability of geotextile sewn.

2.4 SECURING PINS

A. Securing pins shall be steel rods or bars conforming to the following:

1. 3/16-inch diameter.

2. Pointed at one end; head on other end, sufficiently large to retain washer.

3. Minimum Length: 12-inches.

B. Steel washers for securing pins shall be:

1. Outside Diameter: Not less than 1-1/2 inches.

2. Inside Diameter: 1/4-inch.

3. Thickness: 1/8-inch.

C. Steel Wire Staples

1. U-shaped.

2. 10-gauge.

3. Minimum 6-inches long.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify manufacturer and product name or number.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in a way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

3.2 LAYING GEOTEXTILE

A. Notify the ENGINEER whenever geotextiles are to be placed. Do not place geotextile prior to obtaining ENGINEER's approval of underlying materials.

B. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.3 ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and extend at least 18-inches beyond toe of slope.

3.4 JOINTS

A. Unseamed Joints

1. Unseamed joints shall be overlapped to the following dimensions unless otherwise indicated:

a. Foundation/Subgrade Stabilization: Minimum 18-inches.

b. Riprap: Minimum 18-inches.

c. Drain Trenches: Minimum 18-inches, except overlap shall equal trench width if trench width is less than 18-inches.

d. Other Applications: Minimum 12-inches.

B. Sewn seams shall be used wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by ENGINEER, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam efficiency shall be minimum 70 percent, verified by preparing and testing minimum of one set of nondestructive samples per acre of each type and weight of geotextile provided. Test according to ASTM D 4884.

2. Type: "J" type seams are preferred, but flat or butterfly seams are acceptable.

3. Stitch Count: Minimum 3 to maximum 7 stitches per inch.

4. Stitch Type: Double-thread chainstitch, Type 401, Federal Standard No. 751a.

5. Stitch Location: 2-inches from geotextile sheet edges, or more if necessary to develop required seam strength.

6. Sewing Machines: Capable of penetrating 4 layers of geotextile.

3.5 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sand bags or other means approved by ENGINEER.

B. Securing Pins

1. Insert securing pins with washers through geotextile, midway between edges of overlaps and 6-inches from free edges.

2. Spacing

Slope	Maximum Pin Spacing, feet
Steeper than 3:1	2
3:1 to 4:1	3
Flatter than 4:1	5

3. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.

4. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.

3.6 PLACING PRODUCTS OVER GEOTEXTILE

A. Notify ENGINEER before placing material over geotextile,. Do not cover installed geotextile prior to receiving authorization from the ENGINEER to proceed.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as indicated below.

3.7 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way that will completely envelope granular drain material to be placed in trench and with indicated overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to grade, fold geotextile over top of granular drain material, unless otherwise indicated. Maintain overlap until overlying fill or backfill is placed.

3.8 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Sew joints where wave runup may occur.

3.9 GEOTEXTILE-REINFORCED EARTH WALL APPLICATIONS

A. Sew exposed joints; extend sewn seams minimum 3-feet behind face of wall.

B. Protect exposed geotextile from damage and deterioration until permanent facing is applied.

3.10 SILT FENCE APPLICATIONS

A. Install geotextile in one piece or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to a wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.

3.11 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile. Repair damaged geotextile by placing patch of undamaged geotextile over damaged area plus at least 18-inches in all directions beyond damaged area. Remove interfering material as necessary to expose damaged geotextile for repair. Sew patches or secure them with pins and washers, as indicated above for securing geotextile, or by other means approved by ENGINEER.

3.12 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in ENGINEER's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

END OF SECTION

SECTION 31 35 26 - EROSION CONTROL BARRIER

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide erosion control barriers, complete and in place, in accordance with the Contract Documents

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals.

B. Product Data: Manufacturer's catalog sheets on geotextile fabrics.

PART 2 -- PRODUCTS

2.1 FABRIC

A. Fabric may be woven or non-woven, made from polypropylene, polyethylene, or polyamid, and shall contain sufficient UV inhibitors so that it will last for 2 years in outdoor exposure.

B. Fabric shall have the following properties:

Parameter	Standard Method	Value
Grab tensile strength	ASTM D 4632	100 lb
Burst strength	ASTM D 3786	200 psi
Apparent opening size	ASTM D 4751	Between 200 and 70 sieve size

C. Fabric Manufacturer, or equal

1. **Mirafi**

2.2 POSTS

A. Posts shall be wood, at least 2-inches by 2-inches, at least 6-feet long.

2.3 FENCING

A. Woven wire fabric fencing shall be galvanized, mesh spacing of 6-inches, maximum 14-gauge, at least 30-inches tall.

2.4 FASTENERS

A. Fasteners to wood posts shall be steel, at least 1-1/2 inches long.

PART 3 -- EXECUTION

3.1 PREPARATION

A. Provide erosion control barriers at the indicated locations and as required to prevent erosion and silt loss from the Site.

B. CONTRACTOR shall not commence clearing, grubbing, earthwork, or other activities which may cause erosion until barriers are in place.

3.2 INSTALLATION

A. Barrier systems shall be installed in such a manner that surface runoff will percolate through the system in sheet flow fashion and allow sediment to be retained and accumulated.

B. Attach the woven wire fencing to the posts that are spaced a maximum of 6 feet apart and embedded a minimum of 12-inches. Install posts at a slight angle toward the source of the anticipated runoff.

C. Trench in the toe of the filter fabric barrier with a spade or mechanical trencher so that the downward face of the trench is flat and perpendicular to the direction of flow. Lay fabric along the edges of the trench. Backfill and compact.

D. Securely fasten the fabric materials to the woven wire fencing with tie wires.

E. Reinforced fabric barrier shall have a height of 18-inches.

F. Provide the filter fabric in continuous rolls and cut to the length of the fence to minimize the use of joints. When joints are necessary, splice the fabric together only at a support post with a minimum 6-inch overlap and seal securely.

3.3 MAINTENANCE

A. Regularly inspect and repair or replace damaged components of the barrier. Unless otherwise directed, maintain the erosion control system until final acceptance; then remove erosion and sediment control systems promptly.

B. Remove sediment deposits when silt reaches a depth of 6-inches or 1/2 the height of the barrier, whichever is less. Dispose of sediments on the Site, if a location is indicated on the Drawings, or at a site arranged by the CONTRACTOR which is not in or adjacent to a stream or floodplain.

END OF SECTION

SECTION 31 62 19 – STEEL SHEET PILE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide structural steel piles, all in accordance with the requirements of the Contract Documents.

B. This work consists of furnishing of all equipment, materials, techniques, supervision, labor and incidentals for providing and installing steel sheet pile, walers and accessories using driving equipment without the aid of a water jet.

C. No equipment shall be placed beyond the existing slope break. No damage to the bank slopes, adjacent structures and properties will be allowed. Any damage shall be repaired to the satisfaction of OWNER and at no expense to the OWNER.

D. All mobilization and demobilization activities, supplies, installation and construction works shall be performed from land or barge. The Contractor shall familiarize himself/herself with the site limited access working space, barge loading locations as well as for the height, width, and clearance of the bridges and overhead cables to select proper equipment and routes to access the Site.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only. In case of conflict between the requirements of this Section and those of a listed document, the requirements of this Section shall prevail.

1. AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC	Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts
AISC	Manual of Steel Construction

2. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
ASTM A 325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 409	Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A 328	Standard Specification for Steel Sheet Piling
ASTM A 572	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A 690 Standard Specifications for High-Strength Low-Alloy Steel H-Piles and Sheet Piling for Use in Marine Environments

ASTM A 722 Standard Specification for Uncoated High-Strength Steel Bar for Pre-stressing Concrete

3. AMERICAN WELDING SOCIETY (AWS)

AWS D1.1 Structural Welding Code – Steel

1.3 PERFORMANCE REQUIREMENTS

A. Select methods and equipment to furnish and install sheet pile that are compatible with ground conditions described in the boring logs included in the Contract Documents, and with requirements for ground surface and subsurface settlement specified in Articles 1.4 and 1.8 of this Specification Section.

1.4 ALLOWABLE GROUND SURFACE AND SUBSURFACE movement and SETTLEMENTS

A. Control ground settlements as necessary to prevent settlement damage to existing utilities and structures along the sheet pile alignment.

B. Tolerance for ground surface settlement along the top of the slope is the amount of settlement which does not cause damage to existing surface utilities and structures or 0.08 foot, whichever is less.

1.5 CONTRACTOR QUALIFICATIONS

A. The Contractor's key personnel (Superintendent, engineer, technical representatives, foreman, subcontractors, etc.) that will be performing the actual work on site for sheet pile installation shall have previous and relevant experience with the type and complexity of sheet pile installation in marine environment using sheet pile driving methods.

B. The Contractor shall assign an Engineer with at least ten (10) years of experience in the design and construction of permanent sheet pile system to permanently supervise the work; operators and on-site supervisors shall have a minimum of five (5) years experience installing permanent sheet pile with the Contractor's organization.

1.6 CONTRACTOR SUBMITTALS

A. All CONTRACTOR submittals shall be in accordance with the requirements of Section 01 33 00 - Contractor Submittals.

B. For Approval by the OWNER. Submit the following a minimum of 30 calendar days prior to ground anchor and sheet pile installation unless noted otherwise.

1. Preconstruction Survey: Surveyed location of the proposed steel sheet pile based on the survey monuments included in the Contract Drawings. The location of all Work Points of the steel sheet pile alignment shall be marked in the field using long stable stakes painted with visible paint and sticking out of the water surface 2 feet minimum. The OWNER will review the submittal and field inspect the marked Work Points. The Contractor submittal and marked location of the project features on the ground will be reviewed and verified by the OWNER prior to start of the construction work.

2. Alignment Layout Verification: Prior to any construction, Contractor shall stake sheet pile alignment, anchor locations and, locate the trees to be pruned for OWNER inspection and approval.

3. Detail layout of sheet pile, installation procedure and sequence of sheet pile, walers, anchors, backfilling and landscaping.

4. Shop Drawings: Detail drawings for sheet piling and accessories including fabricated sections shall show complete piling dimensions and details, driving sequence, location of piling, and coatings. Detail connections of sheet piles, walers, and anchors. All detail drawings shall include details and dimensions of templates and other temporary guide structures for installing piling. Detail drawings shall provide the method of handling piling to prevent permanent deflection, distortion or damage to piling interlocks in the barge(s) and off-site storage areas.

5. Complete descriptions of sheet pile driving equipment including hammers, extractors, protection caps and other installation appurtenances.

6. Pile Schedule: The Contractor shall provide written notification to the Engineer of the scheduled date for installation of sheet piling at least 30 calendar days in advance of that date. The Contractor shall also describe the proposed method to install the sheet piling from the barge(s) if used.

7. The Contractor shall submit a list containing at least three (3) projects successfully completed within the last five (5) years that included installation of steel sheet pile of similar scope and complexity to the Work using barge system (if using barge for installation of steel sheet piles). For each project, the Contractor shall include with this submittal, at a minimum: (1) name of client contact, address, and telephone number; (2) location and description of the project; (3) contract value; and (4) scheduled completion date and actual completion date for the project.

8. Resumes of Contractor's Staff: The Contractor shall submit resumes of his staff in accordance with Article 1.5 of this Specification Section. Only those individuals designated as meeting the qualification requirements shall be used for the project. The Contractor cannot substitute for any of these individuals without written approval of the OWNER. The OWNER may suspend the work if the Contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in Contract Time resulting from the suspension of work will be allowed.

9. Reports

    a. Materials Tests: Certified material test reports, including mill test reports, showing that sheet piling and appurtenant metal materials meet the specified requirements shall be submitted for each shipment and identified with specific lots prior to installing materials.

    b. Welding: Welding procedures and operator qualifications shall be submitted for approval.

10. Installation Records: A complete and accurate record of each sheet pile drive shall be submitted within 3 working days of completion of pile driving operation. The record shall indicate the pile location (as driven), date driven, size, driven length, embedded length, final elevations of tip and top, pile weight, blows required for each foot of penetration throughout the entire length of the pile and for every inch of the final 12 inches of penetration, and the total driving time. The record shall also include the type and size of hammer used, the rate of operation, and the type and dimensions of driving helmet and cushion block used. Any unusual conditions encountered during pile installation, such as delays during driving or damage to the pile resulting from driving shall be recorded and immediately reported to the OWNER. The format for driven records shall be submitted by the Contractor for approval by the OWNER.

11. Winter Closure Design: The winter closure design as described in paragraph 3.2.G of this Specification Section shall be submitted for approval a minimum of 30 calendar days prior to installation of the winter closure.

C. Submit for information only

1. Verify location of survey monuments: Thirty (30) calendar days prior to start of any construction activity, the Contractor shall submit the surveyed locations (coordinates and elevation) of the survey monuments as required by Specificaiton Section 02 22 13 – Settlement Monitoring.

2. Sheet Pile Placement Plan: Submit sheet pile placement plan at least thirty (30) calendar days prior to delivery of sheet piles to the job site. Pile placement plan shall include installation sequence and methods for controlling location and alignment of sheet pile from barge(s) at the channel side. The plan shall include construction sequence and methods to maintain stability of channel bank slopes during removal of existing sheet pile and installation of proposed sheet pile. Include instrumentation and monitoring plan according the Plans.

1.7 ENVIRONMENTAL PRECAUTIONS

A. The Contractor shall be responsible for establishing environmental precautions to prevent the spillage of oil and grease, fuel, grouts, waste water, stirring up sediments, and other objectionable materials into the channel waters in accordance with applicable permits, licenses and other State, Federal and local laws, regulations and ordinances. Any violations and required cleanups shall be the sole responsibility of the Contractor.

1.8 SUBSURFACE DATA

A. Boring logs completed for this project and pertinent previous boring logs completed for other projects near the project site are shown on the Drawings. Refer to the Geotechnical Data Reports included as appendices to the Specificaions for boring logs and description of field work completed for this project.

B. Variations may exist in the subsurface between boring locations. Any reference to rock, soil or other material on the Drawings, whether in numbers, words, letters, or lines, may not be representative of the actual subsurface conditions.

C. The CONTRACTOR shall visit the site and shall satisfy itself as to all existing surface and subsurface conditions affecting its work. The information provided in the Geotechnical Data Reports is available to the CONTRACTOR to assist it, at its own risk, in its assessment of subsurface conditions at the site. Prior to bidding, bidding contractors may make their own subsurface investigations to satisfy themselves as to site and subsurface conditions, but such subsurface investigations shall be performed only under time schedules and arrangements approved in advance by the OWNER.

1.9 QUALITY CONTROL

A. The Contractor shall take such steps as necessary to protect the Work, personnel and property as specified in Contract Documents. The OWNER will monitor all aspects of installation and construction of the sheet pile walls. The Contractor shall be aware of the activities required by the OWNER and shall account for these activities in the construction schedule. The Contractor shall correct all deficiencies and nonconformities identified by the OWNER at no additional cost to the OWNER.

B. Independent Testing Laboratories: All sampling, testing and calibration required under this Section shall be performed by an independent materials testing laboratory approved by the OWNER and subcontracted by the Contractor. The OWNER shall be directly furnished with all results from the independent testing laboratory.

C. Records: The Contractor shall keep records for all driving, alignment and inspection, material quantities and certificates, stressing and testing data, and other records as specified herein. Copies of these records shall be submitted to the OWNER on a daily basis, unless otherwise specified.

D. Calibration records, including load gauge pressure curves, shall be maintained by the Contractor for each hydraulic jack system and driving hammer system used for sheet pile installation. The Contractor shall provide calibration certificates for all gauge, hydraulic jack devices and hammer devices prior to starting the work and as necessary or requested by the OWNER during the progress of the work.

PART 2 -- PRODUCTS

2.1 STEEL SHEET PILES

A. General: Sheet piling shall be domestic hot-rolled steel sections, of the type shown on the drawings or an approved alternative section conforming to the requirements of ASTM A 572 Grade 50 or equivalent. Domestic hot-rolled sections conforming to ASTM A690 (or equivalent) are also acceptable. Interlocks shall be free sliding, provide a swing angle suitable for the intended installation, and maintain continuous interlocking when installed. Sheet piling shall be full-length sections of the dimensions shown on the drawings. Fabricated sections shall conform to the requirements herein and the piling manufacturer's recommendations.

B. Buy American Act - The Contractor shall ensure that, to the extent applicable, services provided hereunder comply with any Buy American Act provisions of the Federal Government and/or any similar provisions of the State of Illinois as applicable.

C. Alternative Steel Sheet Piling: Alternative hot-rolled steel sheet piling sections may be substituted for the section shown on the drawings. Piling substituted for the section shown on the drawings shall have as a minimum the properties listed below:

Section	Web Thickness (in)	Section Modulus per Linear Ft of Wall (in^3/ft)
PZ27	0.375	36.49

D. Substituted sections for those shown on the drawings shall have a PZ profile. Substituted sections shall conform to all other requirements of this Specification in addition to the requirements of this paragraph. The Contractor shall provide detailed calculations for any alternative pile section proposed by the Contractor and accepted by the OWNER. The calculations shall include, but not be limited to ground anchor, walers and connection designs. The design calculations shall be signed and sealed by a licensed Structural Engineer registered in the State of Illinois, and submitted to the OWNER for approval. The Contractor is responsible for detailing all revisions to the layout affected by the selected alternative piling. Revised layouts shall be submitted as shop drawings for approval.

E. Splices in steel sheet piles shall be made by a full penetration butt weld of the entire cross-section. Splices in the top 10-feet of the piles will not be permitted. Welding shall be performed by qualified welding operators.

2.2 APPURTENANT METAL MATERIALS

A. Material for walers, plates and structural shapes shall conform to ASTM A572 Grade 50 unless otherwise specified. Welding shall conform to AWS D1.1 with AWS E70XX electrodes.

B. Bolts, nuts, and other appurtenant materials shall conform to the requirements in the sheet piling standards, unless otherwise specified herein. High strength steel bolts for sheeting connections and fabrications shall conform to ASTM A 325 Type 3.

C. Couplers (if used) shall be galvanized.

D. Material for tie backs shall be DSI - Dywidag threaded bar grade 100 No. #11 ASTM A615 with corrosion protection. Alternative tie backs shall be equal or better.

2.3 TESTS

A. Sheet piling and appurtenant materials shall be tested and certified by the manufacturer to meet the specified chemical, mechanical and section property requirements prior to delivery to the site. Testing of sheet piling for mechanical properties shall be performed after the completion of all rolling and forming operations.

2.4 DELIVERY, STORAGE AND HANDLING

A. Materials delivered to the site shall be new and undamaged and shall be accompanied by certified test reports. Storage of sheet piling in the barge(s) and off-site should also facilitate inspection by the OWNER. Sheet piling shall be stored and handled in the manner recommended by the manufacturer to prevent permanent deflection, distortion or damage to the interlocks.

PART 3 -- EXECUTION

3.1 FIELD MEASUREMENTS AND PREPARATION

A. Field Measurements: Contractor shall obtain all field measurements required for proper and adequate fabrication and installation of the work. Exact measurements are the Contractor's responsibility.

B. Preparation: Contractor shall be required to excavate, demolish existing materials, reroute water discharge from storm water outfalls along the channel banks, relocate riprap/obstructions, cut/remove existing anchor ties, remove sheet pile walls, remove timber walls, remove timber piles and debris, cut trees when directed by the OWNER, and otherwise remove or demolish existing materials in order to properly align and install the sheet piling.

3.2 STEEL SHEET PILING INSTALLATION

A. Prior to start sheet pile installation, install instrumentation to monitor ground settlement in accordance with Section 02 22 13 – Settlement Monitoring.

B. Sheet Pile Installation Method: Installation of the sheet pile shall be accomplished using sheet piling driving equipment suitable for the ground conditions to be encountered and considering prevention of structural damage of structures and instability of the channel banks. Contractor shall select means, equipment and methods as per Article 1.3 of this Specification Section.

C. Placing and Installing Sheet Pile

1. Placing: Pilings shall be carefully located as shown on the drawings. Pilings shall be placed plumb with out-of-plumbness not exceeding 1/8 inch per foot of length and true to line. Temporary walers, templates, or guide structures shall be provided to ensure that the pilings are placed and driven to the correct alignment. Pilings properly placed and driven shall be interlocked throughout their length with adjacent pilings to form a continuous diaphragm throughout the length or run of piling wall. Deviation from horizontal alignment shall not exceed three (3) inches.

2. Driving: Prior to driving pilings, a horizontal line shall be painted on both sides of each piling at a fixed distance from the bottom so that it shall be visible above the water/ground line after installation. This line shall indicate the profile of the bottom elevation of installed pilings and potential problem areas can be identified by abrupt changes in its elevation. Piling shall be driven with the proper equipment and by approved methods so as to ensure proper interlocking throughout their lengths. Driving hammers shall be maintained in proper alignment during driving operation by use of leads or guides attached to the hammer. A protecting cap shall be employed in driving when using impact hammers to prevent damage to the tops of pilings. Pilings damaged during driving or pulling out of interlock shall be removed and replaced at the Contractor's expense. Pilings shall be pulled out without the aid of a water jet. Adequate precautions shall be taken to ensure that pilings are driven plumb. If obstructions restrict driving a piling to the specified penetration the obstructions shall be removed or penetrated with a chisel beam. If the Contractor demonstrates to the OWNER that removal or penetration is impractical the Contractor shall make changes in the design alignment of the piling structure as directed by the OWNER to ensure the adequacy and stability of the structure. Pilings shall be driven to depths shown on the drawings and shall extend up to the elevation indicated on the drawings for the top of pilings. Refusal shall be as

determined by the OWNER. Obstructions encountered above the expected refusal elevation shall not be considered refusal. A tolerance of plus or minus 1 inch from the indicated top elevation will be permitted.

D. Cutting-Off and Splicing: Pilings driven to refusal or to the point where additional penetration cannot be attained and are extending above the required top elevation in excess of the specified tolerance shall be cut off to the required elevation at no additional cost to the OWNER. Pilings driven below the required top elevation and pilings damaged by driving and cut off to permit further driving shall be extended as required to reach the top elevation by splicing at no additional cost to the OWNER. Splicing of piles shall be avoided, if possible. Pilings adjoining spliced pilings shall be full length unless otherwise approved. Ends of pilings to be spliced shall be squared before splicing. Pilings shall be spliced together with concentric alignment of the interlocks so that there are no discontinuities, dips or cambers at the abutting interlocks. Spliced pilings shall be free sliding and able to obtain the maximum swing with contiguous pilings. The tops of pilings excessively damaged during driving shall be trimmed when directed by the OWNER and at no cost to the OWNER. Piling cut-offs shall become the property of the Contractor and shall be removed from the site. The Contractor shall cut holes in pilings for bolts, rods, or drains as shown on the drawings or as directed. All cutting shall be done in a neat and workmanlike manner. A straight edge shall be used in cuts made by burning to avoid abrupt nicks. Bolt holes in steel piling shall be drilled or may be burned and reamed by approved methods which will not damage the surrounding metal. Holes other than boltholes shall be reasonably smooth and the proper size for rods and other items to be inserted.

E. Inspection of Driven Piling: The Contractor shall inspect all interlocked joints of driven pilings extending above ground. Pilings found to be out of interlock shall be removed and replaced at the Contractor's expense.

F. Seal Welding: Lift holes remaining in the permanent structure shall be plug welded or covered by a steel plate (minimum 1/4 inch thickness) on the inside of the sheeting (land side) and welded to the surrounding steel.

G. Winter Closure: At the time of cessation of work for an extended period, be it winter conditions or other reasons, details described herein as winter closure shall apply. No rubble removal or site preparation shall be done beyond the limits of the anticipated winter closure until work resumes after the shutdown. The new structure shall be complete up to the winter closure, including installation of ground anchors. The Contractor shall provide a winter closure design for approval by the OWNER. The winter closure shall be designed, as a minimum, to contain the backfill behind the sheet pile, protect the new structure from storm, flood, and other damage, and provide a method for preserving the continuity of the structure after the work resumes.

3.3 SEQUENCE OF SHEET PILE INSTALLATION, STAGED BACKFILLING AND ANCHORING

A. Follow the Contractor’s approved sequence of installation.

3.4 TOLERANCES

A. The sheet pile shall be placed with the following tolerances:

1. Vertical Tolerance: +/- 1 inch.

2. Horizontal Tolerance: +/- 6 inches.

3.5 Appurtenant Metals INSTALLATION

A. All appurtenant metal materials shall be installed in accordance with the Contract Drawings.

B. Bolts: All bolts shall be installed at the proper location and set straight and square with connecting members. Hardened washers shall be provided under heads of bolts. Nuts on bolts shall be drawn up snug tight, and where indicated, threads of bolts shall be peened. Until final acceptance of the completed work, the Contractor shall be required to check, straighten and tighten bolts in any part of the structure. Installation shall conform to the requirements of AISC Specification for Structural Joints using ASTM A325 or A490 Bolts, as applicable.

END OF SECTION

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SECTION 32 11 13 - HMA PAVEMENT AND CONCRETE RESTORATION

PART 1 -- GENERAL

1.1 REQUIREMENTS

A. Hot-mix Asphalt (HMA) pavements, base courses, pavement patches, sidewalk, curb and gutter, and related items shall be in accordance with the latest edition of Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction (SSRBC) and as supplemented by the Contract Documents.

B. The CONTRACTOR shall provide temporary CLASS D patches, complete and in place, in accordance with the Contract Documents.

C. The CONTRACTOR shall also remove and replace curbs and gutters, and sidewalks to the lines and grades and dimensions required to match pre-construction conditions for a complete installation in accordance with the Contract Documents and Sections 606 and 424 of the IDOT SSRBC.

D. Removal of pavement, sidewalk, and curb and gutters shall be performed in accordance with Section 440 of the IDOT SSRBC.

E. Materials for aggregate base shall be IDOT Type B material in accordance with the applicable portions of the IDOT SSRBC, Section 351. Aggregate Base shall be minimum 4-inches thick or as directed by the ENGINEER to match the existing conditions.

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals. Include materials testing reports, job-mix formulas, and other pertinent information satisfactory to the ENGINEER.

B. **Suitability Tests of Proposed Materials:** Tests for conformance with the SSRBC shall be performed prior to start of the WORK. The samples shall be identified to show the name of the material, aggregate source, name of the supplier, contract number, and the segment of the WORK where the material represented by the sample is to be used. Results of all tests shall be submitted to the ENGINEER for approval. Materials to be tested shall include aggregate base, coarse and fine aggregate for paving mixtures, mineral filler, and asphalt cement.

C. **Trial Batch:** Before placing any paving material, a testing laboratory acceptable to the ENGINEER shall prepare a trial batch of asphalt concrete for each job-mix formula to be used by the CONTRACTOR for the WORK. The trial batch shall be prepared using the aggregates and asphalt cement proposed by the CONTRACTOR, and approved by the ENGINEER. The compacted trial batch shall provide a basis for computing the voids ratio, provide an indication of the optimum asphalt content, and establish a basis for controlling compaction during construction. The cost of not more than 2 laboratory trial batch tests will be paid by the OWNER but the CONTRACTOR shall be responsible for the materials. Performing and paying for any additional trial batch testing shall be the CONTRACTOR's responsibility.

PART 2 -- PRODUCTS

A. PERMANENT CLASS D PATCHES Following proper compaction of the granular trench backfill, minimum 2.5 inches of Polymerized Hot-Mix Asphalt Binder Course shall be placed and compacted in accordance with Section 442 of the IDOT SSRBC. Bituminous Materials (Prime Coat) shall be applied where required according to Section 442 of the SSRBC. Minimum 1.5 inches of Polymerized Hot-Mix Asphalt Surface Course shall be placed in accordance with Section 406 of the IDOT SSRBC.

B. Materials for aggregate base shall be IDOT Type B material in accordance with the applicable portions of the IDOT SSRBC, Section 351.

C. This work is limited to three (3) days. After the three (3) days all lanes shall be reopened for traffic and the permanent Class D patch shall be fully curried and completed.

2.2 CONCRETE

A. Concrete for sidewalks, and curb and gutters shall be in conformance with the applicable portions of the IDOT SSRBC, Sections 424 and 606, respectively.

PART 3 -- EXECUTION

3.1 SUBGRADE PREPARATION

A. The subgrade shall be prepared in accordance with Section 31 30 00 - Earthwork as applicable to roadways and embankments. The surface of the subgrade after compaction shall be hard, uniform, smooth and true to grade and cross-section. Subgrade for pavement shall not vary more than 0.02-foot from the indicated grade and cross-section. Subgrade for base material shall not vary more than 0.04-foot from the indicated grade and cross-section.

3.2 AGGREGATE BASE

A. Aggregate base shall be provided where indicated to the thickness indicated. Imported aggregate bases shall be delivered to the Site as uniform mixtures and each layer shall be spread in one operation. Segregation shall be avoided and the base shall be free of pockets of coarse or fine material. Where the required thickness is 6 inches or less, the base materials may be spread and compacted in one layer. Where the required thickness is more than 6 inches; the base material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 6 inches. The relative compaction of each layer of aggregate base shall be not less than 95 percent of maximum density when measured in accordance with ASTM D 1557. The compacted surface of the finished aggregate shall be hard, uniform, smooth and at any point shall not vary more than 0.02-foot from the indicated grade or cross-section.

3.3 PRIME COAT

A. Prior to placing of pavement a prime coat of cutback asphalt shall be applied to the compacted base or subgrade at a rate between 0.10 and 0.25 gal/sq yd.

3.4 TACK COAT

A. A tack coat shall be applied to existing paved surfaces where new asphalt concrete is to be placed on existing pavement. It shall also be applied to the contact surfaces of all

cold pavement joints, curbs, gutters, manholes and the like immediately before the adjoining asphalt pavement is placed. Care shall be taken to prevent the application of tack coat material to surfaces that will not be in contact with the new asphalt concrete pavement. Diluted emulsified asphalt shall be applied at the rate of 0.05 to 0.15 gal/sq yd. Undiluted emulsified asphalt shall be applied at the rate of 0.025 to 0.075 gal/sq yd. Paving asphalt shall be applied at the rate of approximately 0.05 gal/sq yd.

3.5 ASPHALT CONCRETE

A. At the time of delivery to the Site, the temperature of mixture shall not be lower than 260 degrees F or higher than 320 degrees F, the lower limit to be approached in warm weather and the higher in cold weather.

B. Asphalt concrete shall not be placed when the atmospheric temperature is below 40 degrees F or during unsuitable weather.

C. The asphalt concrete shall be evenly spread upon the subgrade or base to such a depth that, after rolling, it will be of the required cross-section and grade of the course being constructed.

D. The depositing, distributing, and spreading of the asphalt concrete shall be accomplished in a single, continuous operation by means of a self-propelled mechanical spreading and finishing machine designed specially for that purpose. The machine shall be equipped with a screed or strike-off assembly capable of being accurately regulated and adjusted to distribute a layer of the material to a definite pre-determined thickness. When paving is of a size or in a location that use of a self-propelled machine is impractical, the ENGINEER may waive the self-propelled requirement.

E. Spreading, once commenced, shall be continued without interruption.

F. The mix shall be compacted immediately after placing. Initial rolling with a steel-wheeled tandem roller, steel three-wheeled roller, vibratory roller, or a pneumatic-tired roller shall follow the paver as closely as possible. If needed, intermediate rolling with a pneumatic-tired roller shall be done immediately behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In areas too small for the roller, a vibrating plate compactor or a hand tamper shall be used to achieve thorough compaction.

G. Upon completion the pavement shall be true to grade and cross-section. When a 10-ft straightedge is laid on the finished surface parallel to the center of the roadway, the surface shall not vary from the edge of the straightedge more than 1/8-inch except at intersections or changes of grade. In the transverse direction, the surface shall not vary from the edge of the straightedge more than 1/4-inch.

H. The relative density after compaction shall be 95 percent of the density obtained by using ASTM D 1188 or D 2726. A properly calibrated nuclear asphalt testing device shall be used for determining the field density of compacted asphalt concrete, or slabs or cores may be laboratory tested in accordance with ASTM D 1188.

3.6 CURB AND GUTTER AND SIDEWALK CONSTRUCTION

A. The concrete curbs IDOT Type B-6.12 and sidewalks shall be replaced in kind on a prepared smooth subgrade of uniform density. Large boulders and other obstructions shall be removed to a minimum depth of 6 inches below the finished subgrade elevation and the replaced with suitable material that shall be thoroughly compacted by rolling or

tamping. The CONTRACTOR shall furnish a template and shall thoroughly check the subgrade prior to depositing concrete.

B. Concrete for curbs and sidewalks shall be formed mixed placed and finished in conformance with the requirements of Division 3 except as modified herein. Concrete shall be cured with a clear membrane curing compound that shall be applied at a uniform rate of one gallon per 200 square feet in accordance with the requirements specified hereinbefore under pavement construction. Sidewalks shall be given a light broom finish.

3.7 CURB AND GUTTER

A. Curbs IDOT Type B-6.12 shall be replaced in kind in uniform sections 10 feet in length except where shorter sections are necessary for closure or arcs along curves. The sections shall be separated by sheet metal templates set perpendicular to the face and tip of the curve and not less than 2 inches longer than the depth of the curb. The templates shall be held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape but shall be removed while the forms are still in place.

B. After the concrete has sufficiently set for a minimum of 12 hours the CONTRACTOR shall remove the forms and backfill the spaces on each side. The earth shall be compacted in a satisfactory manner without damage to the concrete work. Minor defects shall be filled with a mortar composed of one part Portland cement and two parts fine aggregate.

END OF SECTION

SECTION 32 13 00 – TREE PROTECTION AND TRIMMING

PART 1 -- GENERAL

1.1 SUMMARY

A. Scope of Work: The work includes labor, equipment, and materials necessary for existing tree relocation, protection and trimming.

1.2 QUALITY ASSURANCE

A. Standards: Code of Standards of the American Nursery and Landscape Association and the American Standard for Nursery Stock and American National Standards Institute Standard for Tree Pruning.

B. Review schedule and specification in preconstruction meeting.

1.3 CONTRACTOR SUBMITTALS

A. Schedule and Work Plan: Submit detailed schedule and work plan for each part of the work.

B. Chain Link Protection Fencing: Submit proposed methods and sequence of site preparation to the ENGINEER for review prior to start of work.

1.4 PROTECTION

A. Use every precaution to prevent damage to and provide protection, as necessary, of existing plant material. Repair or replace to original condition, as acceptable to the ENGINEER and at no additional cost to the OWNER, any material or work damaged or destroyed while performing work.

B. Vegetation protection fencing shown on drawings are minimum required for work. The CONTRACTOR shall be responsible for providing additional temporary fencing during the work as necessary to protect vegetation.

PART 2 -- PRODUCTS

2.1 CHAIN LINK FENCE FOR TREE PROTECTION

A. Frame: ASTM A120, schedule 40 steel pipe, standard weight, one piece without joints.

B. Fabric Two-inch diamond mesh steel wire, interwoven, 11 gauge, top selvage twisted tight, bottom selvage knuckle end closed. RS RR-F-191, type 1, zinc-coated steel.

C. Line Posts: 1.9 inch diameter steel pipe.

D. Corner and Terminal Posts: 2.88 inch steel pipe.

E. Fittings: Sleeves, bonds, clips, rail ends, tension bars, fasteners and fittings; steel.

F. Tension Wire: 6 gauge thick steel, single strand.

G. Top Rail and Post Braces: 1-5 inch outer diameter schedule 40 galvanized pipe.

PART 3 -- EXECUTION

3.1 PREPARATION

A. Flagging of Existing Trees: Flag trees to remain and to be removed with a bright colored ribbon. Notify the ENGINEER at least 48 hours prior to commencing of work to verify all trees that are flagged.

B. Do not park any vehicles or equipment, nor store any materials or stockpiled soil, nor dispose of building materials, chemicals, petroleum products or other detrimental substances within drip line of tree. Protect trees from flame, smoke and heat. Construction access to site shall not occur beneath drip line of trees.

3.2 EXISTING TREES TO REMAIN

A. General:

1. Protect root systems from smothering. Restrict foot traffic to prevent excessive compaction of soil over root systems.

2. Individual trees and areas shown to remain shall be protected by six (6) foot high chain link fence. Install fencing before site preparation, grading and clearing and grubbing operations.

3. Under no circumstances shall the Contractor remove existing trees designated to remain for his/her convenience or ease of construction.

4. Prior to installation, stake the location of protection fencing for approval by the ENGINEER. Location stakes or marking shall be placed not greater than ten (1O) feet on-center.

B. Excavate within drip line of trees only where shown:

1. Where trenching for utilities is required within drip line, tunnel under or around roots by hand digging. Do not cut main lateral roots or tap roots. The CONTRACTOR shall notify the ENGINEER prior to cutting roots over 3-inch diameter. Roots up to and including 3/4-inch shall be cut by hand saws. Do not leave roots exposed to sun or drying for more than 24 hours. Protect all exposed roots with moist organic mulch or burlap and backfill as soon as possible.

2. Where excavating for new construction is required within drip line of tree, excavate by hand to minimize damage to roots and perform as follows:

a. Use narrow tine spading forks and comb soil to expose roots.

b. If main lateral roots are immediately adjacent to location of new construction cut roots three (3) inches from new construction.

c. Do not allow exposed roots to dry out before permanent backfill is placed.

d. Provide temporary earth cover, or pack with peat moss and wrap with burlap.

e. Water and maintain in moist condition until covered with backfill.

C. Guarantee:

1. Trees which are protected within fencing that become damaged or die shall be replaced with trees of the same species and equal size.

2. Damaged and destroyed trees which cannot be replaced shall be paid for at the rate of $50.00 per square inch of cross sectional area measured three (3) feet above existing grade for trees up to and including six (6) inch caliper, and at the rate of $100.00 per square inch of cross sectional areas measured three (3) feet above existing grade for trees greater than six (6) inches caliper. This amount shall be credited to the OWNER.

3. These damaged and destroyed trees shall be removed from the site, the stumps grubbed and the ground surface repaired with all costs borne by the CONTRACTOR.

3.3 TRIMMING OF EXISTING TREES

A. General: Engage a qualified arborist to remove branches from tree. No pruning unless approved and directed by the ENGINEER.

B. Pruning: Cut branches with sharp pruning instruments and do not break or chop. Prune flush with trunk surface.

C. Trimming: Symmetry of the tree shall be preserved; no stubs or splits or torn branches left; clean cuts shall be made close to the trunk or large branch. Spikes shall not be used for climbing live trees. All cuts over 1-1/2 inches in diameter shall be coated with an asphaltic emulsion material.

END OF SECTION

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SECTION 32 13 15 - AGGREGATE FOR TEMPORARY ACCESS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This WORK shall consist of construction and maintenance of an aggregate surface course for the purpose of providing access to private property and access through public rights-of-way.

PART 2 - MATERIALS AND EXECUTION

2.1 REFERENCE SPECIFICATIONS

A. Aggregate surface shall be constructed in accordance with the applicable portions of Section 402 of the IDOT Standard Specifications except that the equipment required for the WORK will be as directed by the Engineer.

B. Maintenance shall consist of placing and compacting additional aggregate of the same type and gradation as the surface aggregate.

C. When the use of the temporary roads and approaches is discontinued, the surface aggregate placed in its construction and maintenance shall be removed and utilized, if in suitable condition, in the permanent construction or otherwise disposed of as specified in Article 202.03 of the IDOT Standard Specifications.

D. This WORK will not be compensated separately and shall be incidental to the lump sum cost in the Bidding Schedule.

END OF SECTION

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SECTION 32 17 23 - PAVEMENT MARKING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide pavement marking and striping, complete and in place, in accordance with the Contract Documents.

1.2 QUALITY ASSURANCE

A. Perform WORK in accordance with the requirements of local agencies.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. Paint shall be factory mixed, quick drying and non-bleeding type.

B. Color shall be as per IDOT requirements.

C. Striping, arrows, lane markers and stop bars shall be provided with paint containing reflective additive.

D. Thermoplastic Paint: Conform to the applicable IDOT Standard Specifications for Road and Bridge Construction Article 780.05.

E. Traffic Paint: Conform to the applicable IDOT Standard Specifications for Road and Bridge Construction Article 780.06.

PART 3 -- EXECUTION

3.1 TRAFFIC AND LANE MARKINGS

A. Sweep dust and loose material from the sealed surface.

B. Apply paint striping as indicated with suitable mechanical equipment to produce uniform straight edges. Apply not less than 2 coats at manufacturer's recommended rates of application.

C. Protect pavement markings until completely dry in accordance with manufacturer's recommendations.

END OF SECTION

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SECTION 32 31 13 – CHAIN LINK FENCING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide chain link fencing and gates and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Chain link fencing, gates, accessories, fittings, and fastenings shall be products of a single manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings

1. Manufacturer's technical data, product specifications, standard details, certified product test results, installation instructions and general recommendations.

2. Scale layout of fencing, gates, and accessories. Drawings shall show fence height, post layout, including sizes and sections; post setting and bracing configuration, details of gates and corner construction, barbed wire support arms; and other accessories which may be necessary.

C. Samples: Samples of proposed fence components, at least 12-inches long, to illustrate the selected color and finish.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Dimensions indicated herein for roll-formed pipe and H-sections are outside dimensions, excluding coatings.

B. Fence fabric height shall be 8-feet unless otherwise indicated.

C. Fencing materials shall be hot-dip galvanized after fabrication.

2.2 STEEL FABRIC

A. Fence fabric shall be No. 9 gauge steel wire, 2-inch mesh, with top selvages knuckled and bottom selvages twisted and barbed.

B. Fabric Finish: Fabric shall be galvanized in conformance with ASTM A 392 - Zinc-Coated Steel Chain Link Fence Fabric, Class II, with not less than 2.0 ounces zinc per square foot of coated surface.

2.3 FRAMING AND ACCESSORIES

A. Steel Framework, General: Unless otherwise indicated, framework components shall be fabricated of galvanized steel conforming to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless, or ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products, with not less than 1.8 ounces zinc per square feet of coated surface.

1. Fittings and accessories shall be galvanized in accordance with ASTM A 153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware, with zinc weights per Table I of that standard, except that no coating shall be less than 1.8-ounce zinc per square foot of coated surface.

B. End, Corner and Pull Posts: Posts shall be one-piece without circumferential welds, 3-inch schedule 40 pipe, 5.79 pounds per linear foot.

C. Line Posts: Line posts shall be spaced no more than 10-feet on center and shall be 2-1/4 inch “H” column section, 4.1-pounds per linear foot, or schedule 40, 2-1/2 inch pipe, 3.65-pounds per linear foot.

D. Gate Posts: Gate posts shall be 4-inch schedule 40 pipe, 9.1-pounds per linear foot.

E. Top Rail: Top railing shall be provided in manufacturer’s longest lengths, with expansion type couplings, approximately 6-inches long, for each joint. Fence design shall provide positive, secure attachment of top rail to each gate post, corner post, pull post and end post. Top rail and braces shall be 1-5/8 inch schedule 40 pipe, 2.27-pounds per linear foot, or 1-1/2 inch “H” column section, 2.00-pounds per linear foot.

F. Tension Wire: Tension wire shall be located at the bottom of the fabric and shall consist of No. 7 gauge coated coil spring wire of metal and finish to match fabric. Tension wire shall be interlaced with the fabric or attached to the fabric along the extreme bottom of the fence. Tension wire attachment shall be with fabric tie wires at a spacing of no more than 24-inches apart.

G. Fabric Tie Wires: Fabric tie wires shall be No. 9 gauge galvanized steel wire of the same finish as the fabric. Aluminum ties shall not be used. Ties shall be spaced 14-inches apart on posts and 24-inches apart on rails.

H. Post Brace Assembly: Post brace assembly shall be manufacturer’s standard adjustable brace assembly provided at each end post, gate post and at both sides of each corner post and intermediate brace post. Material used for brace shall be same as top rail. Truss bracing between line posts shall be achieved with 0.375-inch diameter rod and adjustable tensioner.

I. Post Tops: Post tops shall be weather-tight closure caps, designed for containment of top rail and positive permanent attachment to post. One cap shall be provided for each post.

J. Stretcher Bars: Stretcher bars shall be one-piece lengths equal to the full height of the fabric, with minimum cross-section of 3/16-inch by 3-1/2 inch. One stretcher bar shall be provided for each gate and end post, and 2 for each corner and intermediate brace post.

K. Stretcher Bar Bands: Stretcher bar bands shall be one-piece fabrications designed to secure stretcher bars to end, corner, intermediate brace, and gate posts. Bands shall

have a minimum cross-section of 1/8-inch by 3/4-inch. Stretcher bar bands shall be spaced no more than 15-inches on center.

2.4 GATES

A. Fabrication: Perimeter frames of gates shall be fabricated from same metal and finish as fence framework. Gate frames shall be assembled by welding or with fittings and rivets for rigid, secure connections. Welds shall be ground smooth. Gate frames and any ungalvanized hardware, shall be hot-dip galvanized after fabrication. Horizontal and vertical members shall be provided to ensure proper gate operation and attachment of fabric, hardware and shall be hot-dip galvanized after fabrication.

1. Fabric for gates shall match fence fabric, unless otherwise indicated. Fabric shall be installed with stretcher bars at all perimeter edges. Stretcher bars shall be attached to gate frame with stretcher bar bands spaced no more than 15-inches on center.

2. Each gate shall be diagonally cross-braced with a 3/8-inch diameter adjustable length truss rod to ensure frame rigidity without sag or twist.

B. Swing Gates: Perimeter frames of swing gates shall be constructed of the same pipe or “H” column members as the top rails and shall be fabricated by welding. Welds shall be ground smooth prior to hot-dip galvanizing.

1. Hardware and accessories shall be provided for each gate, galvanized in conformance with ASTM A 153, and in accordance with the following:

a. Hinges: Hinges shall be of size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Three hinges shall be provided for each leaf 6-feet or more in height.

b. Latch: Latch shall be forked type or plunger-bar type, permitting operation from either side of the gate, with padlock eye as an integral part of the latch.

c. Keeper: Keeper shall be provided which automatically engages the gate leaf and holds it in the open position until it is manually released.

d. Double Gates: Gate stops shall be provided for double gates, consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Locking device and padlock eyes shall be provided as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.

2.5 RELATED ITEMS

A. Concrete: Concrete shall be provided according to Section 03 31 00 - Cast-In-Place Concrete.

B. Nuts, bolts and screws shall be steel, minimum size 3/8-inch diameter, hot-dip galvanized after fabrication.

2.6 MANUFACTURERS

A. Manufacturer's Qualifications: Chain link fencing and gates shall be products of a single manufacturer which has been successfully engaged in the production of such items for a period of at least 5 years.

B. Installer's Qualifications: Installation of the chain link fence shall be by the manufacturer or by a firm accepted and licensed by the manufacturer.

C. Manufacturers, or equal

1. **American Fence Corp.**

2. **Anchor Fence, Inc.**

3. **United States Steel**

PART 3 -- EXECUTION

3.1 INSPECTION

A. Prior to commencing installation, require Installer to inspect all areas and conditions within which WORK of this Section will be performed. Dimensions and clearances shall be verified. Final grading shall be completed and all earth, brush, or other obstructions which interfere with the proper alignment and construction of fencing shall be removed.

3.2 INSTALLATION

A. General: Unless otherwise indicated, all posts shall be set in concrete. Gate and related posts, corner posts, and other critical elements shall be provided with concrete foundations which are designed by an engineer to safely accommodate the loads to which they will be subjected.

B. Excavation: Holes for posts shall be drilled or hand excavated to the diameters and spacings indicated, in firm, undisturbed or compacted soil. Post foundations which are not designed by an engineer shall comply with the following:

1. Holes shall be excavated to a diameter not less than 12-inches or not less than 5 times the largest dimension of the item being anchored, whichever is larger.

2. Depth for holes shall be not less than 40-inches; excavated approximately 4-inches lower than the post bottom, with bottom of posts set not less than 36-inches below finish grade surface.

C. Setting Posts: Line posts shall be spaced at not more than 10-foot intervals, measured from center to center of the posts, parallel to the ground slope. Posts shall be set plumb and shall be centered in holes, 4-inches above the bottom of the excavation, with posts extending not less than 36-inches below finish grade surface.

1. Corner posts shall be installed where changes in the fence lines equal or exceed 15 degrees, measured horizontally.

2. Each post shall be properly aligned vertically and its top aligned parallel to the ground slope. Posts shall be maintained in proper position during placement and finishing operations.

D. Concrete

1. Concrete for footings may be placed without forms, providing the ground is firm enough to permit excavation to neat line dimensions. Prior to placing concrete, the earth around the hole shall be thoroughly moistened.

2. Encasement concrete for footings shall be placed immediately after mixing in a manner such that there will be no concentration of the large aggregates. The concrete shall be consolidated by tamping or vibrating.

3. Concrete footings shall have a neat appearance and shall be extended 2-inches above grade and troweled to a crown to shed water.

4. A minimum of 7 days shall elapse after placing the concrete footings before the fence fabric or barbed wire is fastened to the posts.

E. Bracing: Bracing shall be provided at all ends, corners, gates, and intermediate brace posts. Corner posts and intermediate brace posts shall be braced in both directions. Horizontal brace rails shall be set midway between the top rail and the ground, running from the corner, end, intermediate brace or gate post to the first line post. Diagonal tension members shall connect tautly between posts below horizontal braces.

1. Braces shall be so installed that posts remain plumb when diagonal rod is under proper tension.

F. Intermediate Brace Posts: Where straight runs of fencing exceed 500-feet, intermediate brace posts shall be installed, spaced equally between ends or corners; with additional posts provided as required, such that the spacing between intermediate brace posts does not exceed 500-feet. Intermediate brace posts shall be equivalent in size to corner posts and shall be braced with horizontal brace rails and diagonal tension members in both directions.

G. Top Rails: Top rails shall be run continuously through post caps, bending to radius for curved runs. Expansion couplings shall be provided as recommended by the fencing manufacturer.

H. Center Rails: Center rails shall be provided where indicated. Rails shall be installed in one piece, between posts and flush with posts on fabric side, using special offset fittings where necessary.

I. Tension Wire: Continuous bottom tension wire shall be stretched tight with turnbuckles at end, gate, intermediate, and corner posts. Tension wire shall be installed on a straight grade between posts, with approximately 2-inches of space between finish grade and bottom selvage, unless otherwise indicated. Tension wire shall be tied to each post with not less than 6 gauge galvanized wire.

J. Fabric

1. Chain-link fabric shall be fastened on the secured side of the posts.

2. Fabric shall be stretched and securely fastened to posts. Between posts, top and bottom edges of the fabric shall be fastened to the top rail and bottom tension wire, respectively.

3. Fabric shall be stretched and anchored in such a manner that it remains in tension after the pulling force is released.

K. Tie Wires: Tie wire shall be bent to conform to the diameter of the pipe to which it is attached, clasping pipe and fabric firmly with ends twisted at least two full turns. Ends of wire shall be bent back to minimize hazard to persons or clothing.

1. Fabric shall be tied to line posts with tie wires spaced at 12-inches on center.

2. Fabric shall be tied to rails and braces with tie wires spaced at 24-inches on center.

3. Fabric shall be tied to tension wires, with hog rings spaced 24-inches on center.

L. Stretcher Bars: Fabric shall be fastened to end, corner, intermediate brace, and gate posts with stretcher bars. Bars shall be threaded through or clamped to fabric at 4-inches on center and secured to posts with stretcher bar bands spaced no more than 14-inches on center.

M. Fasteners: Nuts for tension bands and hardware bolts shall be installed on the side of fence opposite the fabric side. Ends of bolts shall be peened or the threads scored to prevent removal of nuts.

N. Galvanized coating damaged during construction of the fencing shall be repaired by application of Galvo-Weld; Galvinox; or equal.

3.3 GROUNDING

A. Fences crossed by powerlines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 150-feet on each side of the crossing.

B. Fences, gates and appurtenances enclosing electrical equipment areas, gas yards, or other hazardous areas shall be electrically continuous and grounded.

C. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be 3/4-inch by 10-foot long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 6-inches below grade.

1. Where driving is impracticable, electrodes shall be buried a minimum of 12-inches deep and radically from the fence. Top of electrode shall be not less than 2-feet or more than 8-feet from the fence.

D. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps so as to create electrical continuity between fence posts, fence fabric, and ground rods. After installation, the total resistance of fence to ground shall not be greater than 25 ohms.

END OF SECTION

SECTION 32 59 90 – TRAFFIC CONTROL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide traffic control as specified herein and as directed by the Engineer to maintain traffic at all times.

PART 2 - MATERIALS AND EXECUTION

A. Traffic control shall be in accordance with the applicable sections of the IDOT Standard Specifications for Road and Bridge Construction, the applicable guidelines contained in the Illinois Manual on Uniform Traffic Control Devices for Streets and Highways, these Specifications and any special details and Highway Standards contained herein and in the Drawings and the Standard Specifications for Traffic Control Items.

Special attention is called to Articles 107.09 and 107.14 and Section 701 of the IDOT Standard Specifications for Road and Bridge Construction and the following Highway Standards relating to traffic control:

701501 701601 701606 701701 701801 702001

The Contractor shall obtain, erect, maintain and remove all signs, barricades, flaggers and other traffic control devices as may be necessary for the purpose of regulating, warning or guiding traffic. Placement and maintenance of all traffic control devices shall be in accordance with the applicable parts of Article 107.14 of the Standard Specifications and the Illinois Manual on Uniform Traffic Control Devices for Streets and Highways. The Contractor shall be solely responsible for ensuring that all traffic control devices are installed and maintained in accordance with applicable state standards.

END OF SECTION

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SECTION 32 92 00 - SEEDING AND SODDING

PART 1 -- GENERAL

1.1 WORK INCLUDED

A. Provide seeding and topsoil to restore disturbed grass areas as specified herein.

B. Provide seeding, erosion control blanket, and topsoil to restore disturbed unpaved areas and area re-graded within the City of Evanston property as shown on the Drawings and specified herein.

PART 2 -- MATERIALS AND EXECUTION

2.1 REFERENCE SPECIFICATIONS

A. Seeding and topsoil shall be in compliance with the applicable portions of the IDOT Standard Specifications, Sections 211, 250 and 251.

B. Sodding and topsoil shall be in compliance with the applicable portions of the IDOT Standard Specifications, Sections 211 and 252.

2.2 SEED

A. Seeding shall be Salt Tolerant Lawn Mixture Class 1A and entire seeding area covered with erosion control blanket.

2.3 SOD

A. Salt Tolerant Sod is required.

- END OF SECTION -

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SECTION 33 05 16 - PRECAST CONCRETE MANHOLES AND VAULTS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide precast concrete manholes and vaults, complete and in place, in accordance with the Contract Documents.

1.2 SPECIFICATIONS, CODES AND STANDARDS

ASTM A 48	Gray Iron Castings
ASTM C 150	Portland Cement
ASTM C 443	Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C 478	Precast Reinforced Concrete Manhole Sections
ASTM C 890	Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
ASTM C 913	Standard Specification for Precast Concrete Water and Wastewater Structures
ASTM C 923	Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals

1.3 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings

1. Show dimensions, locations, lifting inserts, reinforcement, and joints.

2. Structural design calculations for vaults, signed by a registered engineer.

C. Manufacturer’s Certification for Vaults: Written certification that the vault complies with the requirements of this Section.

1.4 QUALITY ASSURANCE

A. Inspection: After installation, the CONTRACTOR shall demonstrate that manholes and vaults have been properly installed, level, with tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2 -- PRODUCTS

2.1 MANHOLES

A. The CONTRACTOR shall provide precast manhole sections and conical sections conforming to ASTM C 478 and the requirements of this Section. Adjusting rings shall be standard items from the manufacturer of the manhole sections. Minimum wall thickness of rings shall be 4-inches if steel reinforced and 6-inches if not reinforced.

B. Axial length of sections shall be selected to provide the correct total height with the fewest joints.

C. Conical sections shall be designed to support cast iron frames and covers under an H-20 loading, unless indicated otherwise.

D. Where the manhole barrel diameter is greater than 48-inches, a flat slab-transition, either concentric or eccentric, shall be used to transition to 48-inch diameter riser sections. Underside of the transition shall be at least 7-feet above the top of the bench.

E. Where indicated on the Drawings, manholes supplied for 48 inch and larger pipes shall be of a ”T” Base-style fabrication. The pipeline portion of the “Base T” section shall conform to ASTM C-76 and be of the same pipe class as the deepest connected sewer. The riser section shall conform to ASTM C-478.

F. Design Criteria: Manhole walls, transitions, conical sections, and base shall be designed per ASTM C 478 for the depths indicated and the following:

1. AASHTO H-20 loading applied to the cover.

2. Unit weight of soil of 120 pcf located above all portions of the manhole.

3. Lateral soil pressure based on saturated soil producing 100 pcf acting on an empty manhole.

4. Internal fluid pressure based on unit weight of 63 pcf with manhole filled from invert to cover with no balancing external soil pressure.

5. Dead load of manhole sections fully supported by the base and transition.

6. Additional reinforcing steel in walls to transfer stresses at openings.

7. The minimum clear distance between the edges of any 2 wall penetrations shall be 12-inches or one-half of the diameter of the smaller penetration, whichever is greater.

G. Joints shall be sealed with o-ring gaskets conforming to ASTM C 443.

H. Concrete for base and channel formation shall be 4000 psi concrete conforming to Section 03 31 00 - Cast-In-Place Concrete.

I. Except were otherwise indicated on the Drawings, manholes shall have a precast concrete base and a factory installed bench.

J. Barrel section to sewer pipe connections shall be sealed with resilient connectors complying with ASTM C 923. Mechanical devices shall be stainless steel.

K. Manhole Manufacturers, or Equal

1. **Welsch Brothers, Inc.**

2. **Hanson Concrete Products, Inc.**

3. **Concrete Specialties, Inc.**

2.2 FRAMES AND COVERS

A. Castings: Castings for manhole frames and covers shall be non-rocking and shall conform to the requirements of ASTM A 48, Class 30. Unless otherwise indicated, cast iron covers and frames shall be heavy traffic type, 30 inches in diameter, with embossed lettering to meet the requirements of the City. Frame and cover shall be designed for H-20 traffic loading.

B. Castings Manufacturers, or Equal

1. **Alhambra Foundry Co., Ltd.**

2. **Neenah Foundry Co.**

3. **Vulcan Foundry, Inc**

2.3 VAULTS

A. The CONTRACTOR shall provide precast vaults designed for the indicated applications and of the sizes indicated.

B. The minimum structural member thickness for vaults shall be 5-inches. Cement shall be Type V portland cement as specified in ASTM C 150. The minimum 28-day concrete compressive strength shall be 4,000 psi. All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.

C. Design Loading: Vaults in areas subject to vehicular traffic shall be designed for H-20 traffic loading. Lateral loads on vaults in all areas shall be calculated from:

	L	=	90 h, plus surcharge of 240 psf in areas of vehicular traffic
Where	L	=	loading in psf
	h	=	depth of fill in feet

D. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.

E. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for

support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.

F. Covers for access openings shall be provided. Frames for covers shall be fabricated from steel, galvanized after fabrication, and shall be integrally cast into the vault concrete sections. All covers shall be tight fitting to prevent the entrance of dirt and debris. Where edge seams are permitted, no gaps greater than 1/16-inch between edges will be accepted. All covers, except round, heavy-weight, cast iron manhole covers, shall have securing mechanisms to hold the covers firmly in place against the effects of repetitious live loads such as pedestrian or vehicle traffic.

G. Where penetration of the pre-cast concrete vault are required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or thin-wall knock-out sections. All openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing. Vaults need not be designed to resist thrust from piping passing through the vault.

PART 3 -- EXECUTION

3.1 GENERAL

A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer's written recommendations. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended. Where no lifting devices are provided, the CONTRACTOR shall follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.

B. Buried pre-cast concrete vaults shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults shall be set to grade and oriented to provide the required dimensions and clearances from pipes and other structures.

C. Prior to backfilling, all cracks and voids in pre-cast concrete vaults shall be filled with non-shrink grout or polyurethane sealant, or both. Around pipe and conduit penetrations, openings shall be sealed with polyurethane sealant. With the authorization of the ENGINEER, grout or a closed-cell flexible insulation may be used as filler material prior to placing a final bed of polyurethane sealant.

END OF SECTION

SECTION 33 90 10 - REINFORCED CONCRETE PIPING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall construct the drain conduits complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASTM C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

ASTM C361 Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.

ASTM C596 Test Method for Drying Shrinkage of Mortar Containing Portland Cement.

1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall furnish certificates to the ENGINEER guaranteeing that the pipe is in compliance with the requirements of these Specifications.

PART 2 -- PRODUCTS

2.1 PIPE MATERIALS

A. **Reinforced Concrete Pipe:** Reinforced concrete pipe shall conform to the requirements of ASTM C 76 for Class V, Wall B, and Type II cement. Pipe shall be designed for a minimum external load of 20 feet of cover.

B. **Joints:** Provide bell and spigot gasketed joints which are rated up to 125 feet of head per ASTM C361.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Installation and testing shall be as required by the Contract Documents and the latest edition of the Standard Specifications for Water and Sewer in Illinois.

- END OF SECTION -

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SECTION 33 90 32 - PRESTRESSED CONCRETE CYLINDER PIPE (PCCP)

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide Prestressed Concrete Cylinder Pipe (PCCP) and appurtenances, complete and in place, in accordance with the Contract Documents.

B. In general, this work consists of furnishing and installing all prestressed concrete cylinder piping, fittings, specials, accessories, joint materials and couplings, bolts, nuts, gaskets, and pressure test for the 60-inch diameters intake pipe and fittings where required in the specifications and on the Drawings.

C. 60-inch diameter pipe shall be embedded cylinder type meeting the requirements of AWWA C301.

D. The 60-inch dimater intake pipe installed offshore shall be with restrained joints using a single-bolt tightening system (**Snap Ring** by Thompson Pipe or approved equal) as detailed on the Drawings or accepted by the ENGINEER.

E. Joining of subaqueous pipe segments shall generally be performed utilizing a vacuum system to create a pressure differential across segments in order to bring pipe joints together. This system shall consist of specialized bulkheads with a submersible pumping unit that is controlled by the CONTRACTOR. The CONTRACTOR shall be responsible for the implementation of monitoring of this system in order to maintain accaprtable pressures such that the pipe is not damaged during installation and that the integrity of pipe joints is maintained.

F. When viable or approved by the ENGINEER, the CONTRATOR may also employ marine harness or draw-bolt connections for the joining a subaqueous pipe segments. Any joints made in this fashion shall not be considered a substitute for pipe restraint. Proper messures must be taken to back off the nuts on the draw bolts after the joint is assembled to allow for future settlement of the pipe.

G. All subaqeous pipe joints shall be testable type ulilzing a threaded test port that will allow for the integrity of joints to be verified as the pipe is installed. These testable joints shall not be consided a substitute for the final pressure testing of the pipe. Pipe segments jointed prior to insertion into the water shall not require testable joints.

H. For longer lengths, it is permissible as approved by the ENGINEER to produce the underwater pipe in two or more sections. Those sections shall be joined by welding or other approved methods as indicated on the Drawings, and shall be lined and coated as specified. Welded joints shall be performed to withstand Internal Design Pressure as indicated in the contract documents. The CONTRACTOR shall handle and install all pipe by use of strongbacks or other approved methods so that excessive deflection or stresses are not imposed on pipe. Maximum allowable pipe length shall be 60 feet. The CONTRACTOR shall provide intermediate block as recommended by the pipe manufacturer.

I. The CONTRACTOR shall be responsible for provision of all items including those required of manufacturers and suppliers.

J. The requirements of Section 31 30 00 – Earthwork and 35 23 21 – Excavation and Backfill for Marine Constation shall apply to the WORK of this Section.

1.2 REFERENCES

A. AWWA C208 - "Dimensions for Fabricated Steel Water Pipe Fittings"

B. AWWA C210 - "Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines:

C. AWWA C301 - "Prestressed Concrete Pressure Pipe, Steel-Cylinder Type"

D. AWWA C304 - "Design of Prestressed Concrete Cylinder Pipe"

E. AWWA M9 - "Concrete Pressure Pipe"

F. ASTM A36 - "Standard Specifications for Carbon Structural Steel"

G. ASTM C150 - "Standard Specification for Portland Cement"

1.3 QUALITY ASSURANCE

A. The pipe manufacturer shall have had a minimum of five (5) years prior experience in manufacturing of the specified pipe and joint types required by the contract documents, and experience in manufacturing pipe of equal or larger diameter pipe and equal pressure rating.

B. The CONTRACTOR shall require and assure that pipe manufacturers shall meet the following requirements:

1. American Concrete Pressure Pipe Association (ACPPA) certification.

2. Experience and capabilities at the same plant producing the pipe as follows:

a. Manufacture of pipe of similar or larger diameter and pressure rating to AWWA Standards. Provide a list of such experience with contacts.

b. List of machinery to be used with it's purpose and capabilities.

c. List of plant standard QA / QC tests and procedures with technical details. An explanation of how any additional requirements of these specifications will be addressed.

C. The CONTRACTOR and the pipe manufacturer shall provide an affidavit of compliance that the pipe, specials, accessories, and materials furnished under this contract shall be in strict accordance with the contract Drawings and specifications, and they shall meet the specified design criteria and perform within the limits as specified.

D. The CONTRACTOR shall provide an affidavit of compliance that the pipe handling and installation are in strict accordance with the specifications, the pipe manufacturer's installation guide, and the best field practices.

E. The CONTRACTOR shall provide an affidavit that the pipe and fittings furnished under this Contract comply with the applicable provisions of these standards including modifications or stipulations.

F. The CONTRACTOR shall submit design calculations to the ENGINEER prior to manufacture of any pipe. No pipe shall be manufactured until required submittals are accepted by the ENGINEER.

G. The OWNER reserves the right to observe pipe, fittings, all Work performed and all material furnished under this Contract at the manufacturer's plant. Such observation shall not relieve the CONTRACTOR or the manufacturer of their responsibility to furnish pipe and fittings and perform the Work in accordance with these Specifications.

1.4 TESTING

A. The Each length of pipe shall be tested in accordance with the most recent version of AWWA C301. Daily certified test pressure reports shall be submitted to the ENGINEER on a weekly basis. Hydrostatic testing procedures shall be submitted prior to testing:

1. All fittings, specials, and appurtenances shall be hydrostatically tested in accordance with the requirements above. The above test may be substituted with nondestructive testing if approved by the ENGINEER. Submit test reports to the ENGINEER when requested within seven calendar days.

2. Certified welders shall perform welds. Welds shall be inspected and tested to provide assurance that welding quality is being maintained. Testing shall be by machine stress testing of coupons, dye penetrant, ultra sound, or other industry standard.

3. All quality control tests conducted by the manufacturer for each production run of pipe shall be maintained and, if requested, submitted to the ENGINEER on a weekly basis.

4. Mill test reports of all steel plates, sheets, or coils used in the fabrication of pipe, fittings, specials, and appurtenances shall be maintained and, if requested, submitted to the ENGINEER.

5. All rejected materials shall be plainly marked and shall be replaced by CONTRACTOR to meet the requirements of these specifications, without additional cost to the OWNER.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. Pipe shall, unless otherwise noted on the contract Drawings, conform to AWWA C301 (latest edition).

B. All pipe and fittings shall be designed in accordance with AWWA C304, latest revision. Additionally, details of the pipe reinforcement showing size and spacing of the reinforcement shall be submitted for pipe and fittings.

C. Pipe shall not be supplied from inventory. CONTRACTOR shall submit a tabulated layout schedule for review by the ENGINEER prior to delivery of any pipe to the Work site.

D. Each straight, bevel end, and other special pipe and each fitting shall be plainly marked on the inside surfaces with its class designation symbol, each bevel end with the amount of the bevel, and each bend with the angle turned thereby, in order that such piping unit may be installed in its proper location in the pipeline. The top of each bevel and pipe and special shall be marked with a stripe of red paint, approximately 1 1/2 inches wide and two feet long, applied along the top center line at each end of such pipe and special. In addition, each pipe and fitting shall be marked with the date of casting, design pressure, size of pipe unit, individual number of pipe unit, and trademark of manufacturer. All inspection reports and production records shall show the pipe unit number.

E. Cement used for the core, slurry, mortar coating, and authorized repairs shall conform to the requirements of ASTM C150 "Specifications for Portland Cement" Type II and shall be from one mill insofar as possible. No fly ash or pozzolanic material shall be used to replace cement. Additionally, mortar shall be tested in accordance with ASTM C497, Method A, once each week or if material source changes, for hardened mortar absorption.

F. Steel plates for pipe cylinders and fittings shall be ASTM A283 (Grade C or D) or ASTM A36. The stress in the steel cylinder shall be a maximum 12,500 psi.

G. Concrete test cylinders shall attain a minimum compressive strength of the larger of 3400 psi (centrifugal test cylinders 4,000 psi) or 220% of the resultant concrete core stress at the time of wrapping and 5,000 psi (centrifugal test cylinders 6,000 psi) in 28 days.

H. All indentations and bulges in the steel cylinder deviating from the cylindrical surface by more than 1/4 inch shall be removed prior to placing concrete. No indentations or bulges in the cylinder of concrete lined cylinder pipe that would cause more than 1/16 inch clear space between the prestressing wire and cylinder after wrapping shall be permitted.

I. The pipe manufacturer shall design the pipe based on the operational pressures and field conditions of the pipe to be installed. The minimum nominal thickness of the steel cylinder shall be 0.0598 inch for all pipe.

J. Specials and fittings shall have a minimum thickness of the steel cylinder not less than 01.188 inches.

K. Prestress wire shall be not smaller than 0.162 inch in diameter.

2.2 PIPE JOINTS

A. Pipe joints shall be per AWWA C301 and as indicated on the project Drawings and these specifications.

B. Bell and spigot joint rings shall be so designed and fabricated that, when the pipe is under design loading, the differential deflection due to external loading shall be kept to a minimum such that there shall be no visible cracking of mortar coating near the join area.

C. No visible initial shrinkage cracks of the coating in the joint areas, joint, and pipe interface shall be allowed. No separations of coating at the joint ring shall be allowed.

D. Joint rings shall be galvanized or zinc coated. Damage to zinc coating shall be painted with galvanized metal primer acceptable to ENGINEER. The minimum thickness of zinc coating shall be 0.004 inch. On finished pipe, the inside circumference of the bell shall not exceed the outside circumference of the spigot by more than 3/16 inch.

E. CONTRACTOR shall submit detail Drawings of pipe joining systems that are proposed for ENGINEER's review.

F. Subaqeous joints shall be supplied with double gasketed, air testable joints. The spigot rings for these joints shall have two equal sized grooves for gaskets separated sufficiently to allow an air pressure test of the small annular space between the gaskets once the joint is assembled. A test port shall be provided through the spigot for introducing air pressure into the area between the gaskets. The CONTRACTOR shall test each of these joints after it is assembled to a gauge pressure 50 psi for a minimum of five (5) minutes. Once the pressure has stabilized, a valve in the air supply line shall be closed. The joint is acceptable if the pressure drop is less than 5 psi. If the joint does not pass this air test, it must be disassembled, re-assembled using new gaskets, and re-tested.

2.3 FITTINGS AND ACCESSORIES

A. In addition to straight lengths of pipe, CONTRACTOR shall furnish all bends, tees, bells, reducers, access manholes, temporary bulkheads, adapters, beveled pipe, outlets, closures, etc., required for complete pipeline construction, as shown on the Contract Drawings or required by field conditions. CONTRACTOR shall provide ENGINEER with list of all such additional pieces.

B. Changes in alignment or grade may be made by breaking the joints of the straight pipe or by the use of beveled end pipe unless single bend fittings are called for on the Drawings. Joint openings shall not exceed one half of the maximum amount of that recommended by the pipe manufacturer. Full bevel and half-bevel pipe shall be manufactured by placing the spigot ring at an angle to its normal position. A full bevel shall be a bevel of one inch per foot of nominal pipe diameter and a half bevel shall be half that amount.

C. The CONTRACTOR shall furnish a suitable number of closure pieces, shorts, half-special adapters, and full bevel adapters, which though not specifically called for on the Contract Drawings, may still be needed for the completion of the Work.

D. The CONTRACTOR shall furnish all necessary neoprene gaskets, joint lubricant suitable for underwater use, and all other equipment, special tools, and accessories that may be required to assemble the pipe or fittings.

2.4 HARDWARE

A. All bolts, studs, and nuts shall be carbon steel for marine harnessed joints with a minimum diameter of 1¼ inches. Bolts, studs, and nuts shall have American National form right-hand machine cut threads which shall be in conformity with ANSI B1.1, Coarse Thread Series, Class 2 Fit, unless otherwise specified.

B. Bolt heads and nuts shall be semi-finished and shall be in conformity with ANSI B18.2, Heavy Series, unless otherwise specified. All nuts shall be hexagonal in shape unless otherwise required.

C. All stainless steel bolts for flange joints shall be in conformity with the current ASTM A193, Type 304. Nuts to be ASTM A194 series 300 stainless steel, other than series 304.

D. The nuts and bolts shall be of sufficient strength to seat the gaskets, including any isolating gaskets in accordance with the gasket manufacturer's recommendations plus resist the hydraulic force in the pipe without failure.

PART 3 -- SUBMITTALS

3.1 The CONTRACTOR shall submit the following items prior to manufacturer of all pipe, fittings, and appurtenances.

A. Pipe laying schedules and Drawings showing full details of pipe, specials, and joints, as well as assembly. Drawings and schedules shall include a list showing size of pipe, serial number, pipe thickness, area of steel in the reinforcing per lineal foot of pipe, and design calculations for the pipe.

B. Detail Drawings and schedules, and a tabulated laying schedule corresponding to the number or identificator painted on the pipes, specials, or fittings.

C. Allowable joint deflections.

D. Concrete compression test reports.

E. Prestressed wire and cylinder test reports.

F. Neoprene gasket test reports.

G. Affidavits of compliance with the contract specifications.

H. Certificate of Design shall be submitted to the ENGINEER prior to the production of the prestressed concrete cylinder pipe and fittings. The certificate shall be signed by a Registered Professional ENGINEER and shall state the following:

1. Codes and specifications that pipe and fittings were designed in conformance with.

2. Type and strength of materials to be used for pipe and fittings.

3. The basis for design of the pipe.

4. Design calculations for prestressed concrete pipe and fittings, including pipe class, wire size, inches of pitch, cylinder thickness, and joints.

5. Concrete mix and mortar mix designs.

I. Details of fittings, specials, and appurtenances.

J. Design details and calculations for any marine harnessed joints and restrained harnessed joints.

K. Manufacturer's installation guide.

L. Manufacturer's standard repair procedures.

M. Manufacturer's written quality control procedures.

N. Quality assurance and proof of design test reports for pipes, specials, and fittings.

O. Support and/or blocking system for grade and alignment of lake bed pipeline.

P. Design and monitoring procedures for vacuum based subaqeous installation system.

PART 4 -- BASIS OF DESIGN

4.1 The following items shall be incorporated into the design of the pipe as provided by the manufacturer.

A. All PCCP, fittings, specials, and appurtenances shall be designed to the following standards:

1. Diameter: 60 inches

2. Type: Embedded Cylinder

3. Standard Pipe Segment Length: 20 feet

4. Maximum Allowable Lay Length of Pre-joined Segments: 60 feet

5. Internal Design Pressure (Operating Pressure + Surge Pressure): 80 psig

6. Anticipated Operating Pressures: 10 to 20 psig

7. Transient Pressure: 0 psig

8. Test Pressure: 80 psig, per AWWA M9. Additional testable joints required on subaqueous connections to hold at 50 psig for 5 minutes.

9. Design Cover (maximum): 23 feet.

10. Joints: AWWA C301, bell and spigot with O-ring gasket; welded or restrained harness-clamp. All subaqueous joints to be double-gasketed, testable type.

11. Joint Protection: Cement mortar at joints, including welded, restrained, and joints made subaqeously.

12. Allowable Joint Deflection: 0.3 degrees or as recommended by the pipe manufacturer.

B. Beam Strength – The pipe shall be capable of acting as a simply supported beam between pipe blocking while underwater prior to backfilling. Maximum deflection shall be limited to 1/360 of the span, and blocking is required so that deflection shall not exceed 1 inch between blocks or 3% of the beam span, whichever is less. The CONTRACTOR shall submit pipe design based on pipe blocking plan with beam deflection calculations for review by ENGINEER.

PART 5 -- EXECUTION

5.1 INSTALLATION

A. General

1. CONTRACTOR shall provide and maintain a marker buoy indicating the end of the completed pipe section in the water. A marker buoy shall also be placed on the existing 36 inch intake crib and remain there throughout the course of the work.

2. CONTRACTOR shall insure proper installation, alignment, and joining of pipe sections together. Mechanical and/or vacuum devices for pulling the pipe together are not allowed.

3. CONTRACTOR's procedure for maintaining alignment and grade shall be submitted for review and acceptance by the ENGINEER.

4. CONTRACTOR shall use a competent experienced hard hat driver to insure the proper installation alignment and joining of pipe sections. Diver shall be responsible to report any improper installation or damage.

5. The CONTRACTOR shall be responsible for the investigation of underwater and underground utilities and structures prior to excavation, and shall take precautions to avoid damaging the utilities and structures in the process of the work unless otherwise indicated in the Contract Documents or approved by the ENGINEER. Any damage to utilities and structures shall be repaired at the CONTRACTOR's expense.

B. PCCP

1. CONTRACTOR shall require the pipe manufacturer to provide a competent representative experienced in the laying of pipe and making of field joints for the pipe. Such representative shall be available to the ENGINEER and to the CONTRACTOR for the purpose of advising them in the proper method of laying the pipe and making watertight joints. It is the intent of this requirement that the representative spends adequate time, with a maximum period of two (2) weeks, at the work site as required to accomplish the desired result of satisfactory installation practice. The presence of such representative, however, shall not relieve the manufacturer or the CONTRACTOR of their responsibility under these specifications.

2. No defective pipe or fittings shall be laid or placed and any piece discovered to be defective after having been laid or placed shall be removed and replaced by a sound and satisfactory piece. Repair of any pipe or fittings shall require prior review and acceptance of the ENGINEER. The completed repair must also meet the acceptance of the ENGINEER. Removal, replacement, and repair of defective pipe or fittings shall be at the CONTRACTOR's expense.

3. Sand, mud, or foreign matter shall not be permitted to enter the pipe. Any foreign matter which may have entered the pipe at any time shall be removed by the CONTRACTOR before any additional pipe is laid. A bulkhead or nightcap shall be installed at the end of the last pipe laid and remain in place until the next pipe is to be laid to prevent sand, mud, or other matter from entering the pipe. The pipelines shall be completely clean and free of foreign matter at all times.

4. All pipe shall be placed at the locations, elevations, and grades as shown on the Contract Drawings. The alignment may be changed slightly as site excavation and pipe cover conditions require, subject to the approval of the ENGINEER. Changes in elevation shall not leave a high spot in the pipeline.

5. A blocking and wedging system shall be used to set and maintain grade and alignment of the pipe as it is laid. The blocking shall be of wood and concrete and of sufficient size and number placed to support the pipe in the trench without damage to the integrity of the pipe and as recommended by the pipe manufacturer. Intermittent blocking or support under center of each pipe section may be required to stabilize the pipe and prevent settlement during pipe laying. Blocking details shall be submitted to the ENGINEER for review and acceptance. After the pipe has been blocked to grade, wood wedges shall be placed on top of the blocking and spiked to the blocking to hold them in place. Intermediate blocking may be required along each pipe section to prevent settlement. This system is to be submitted for review and acceptance by the ENGINEER prior to construction.

6. For pipe laying, as many as three (3) 20-foot lengths of pipe may be made up on land and joined together into one section, not to exceed 60 feet in length. This section shall be moved into position by means of a suitable rigid supporting truss or strongback from which the pipe shall be suspended by slings. Slings shall be designed and spaced so as to distribute the load equally and not to cause injury to the pipe.

7. Prior to lowering pipe into place, the excavated trench shall be checked and determined to have sufficient depth and width to lay the pipe to the alignment and grade required. After a diver has inspected previously installed pipe, and determined that it is clean of sand, mud or foreign matter, and does not exhibit unacceptable settlement since being installed, he shall make up the joint by drawing up the nuts on the drawbolts until bolt and nut both bear firmly against the lug supports. The spigot must be entered the full length into the bell.

8. After the pipe segments are joined, the pipe shall be set on blocking to the line and grade required in the specifications and as shown on the Contract Drawings. After the pipe section has been firmly and securely set on the blocking, wedges or chocks shall be placed on each side and spiked to the blocking to prevent side movement of the section supported. For marine harnessed pipe the drawbolt nuts are then to be backed off ¼ inch to allow for possible settlement. For restrained harnessed joints, the bolts, assembly, and pipe shall be strong enough to resist or accommodate settling and bolts shall remain tightened.

9. At each third pipe section along the pipeline sections laid, intermittent backfilling with stone shall be placed as the pipeline laying progresses. This backfilling shall be on each third pipe length as shown on the Drawings. There shall never be more than four pipe sections, or over 80 feet from the open end of the last pipe laid, without the intermittent backfilling completed. This backfilling shall be done before any additional pipe sections are laid.

10. The trench shall be backfilled as required in by the Drawings and Specifications, with backfill alternated on opposite sides of the pipe so that there will not be unbalanced loading on one side of the pipe.

5.2 ACCESS MAHOLES

A. The CONTRACTOR shall furnish and install access manholes along the 60-inch pipe in the lake, each with cover plates, at the locations shown on the Contract Drawings. All exposed steel surfaces not lined or coated with mortar shall be painted with liquid epoxy. Any areas abraded in handling shall be touched up in the field. Top elevations of access manholes shall be as shown on the Drawings and not higher than the limiting elevations shown on the Drawings where pipe is in shallow water.

5.3 PRESSURE TESTING

A. All intake pipe installed shall be given combined pressure and leakage tests following installation. The pressure and leakage tests shall be done in accordance with AWWA Standard for “Installation of Ductile-Iron Water Mains and Their Appurtenances”, Designation C600, latest edition

B. The test pressure for all testing shall be 80 psig. The duration of testing shall be no less than 2 hours.

C. Pipe may be tested in sections as accepted by the ENGINEER.

D. If the section fails to pass the pressure and leakage test, the CONTRACTOR shall do everything necessary to locate, uncover, and repair or replace the defective pipe, fitting, or joint, all at its own expense and without extension of time for completion of the Work. Additional tests and repairs shall be made until the section passes the specified test.

E. If, in the judgment of the ENGINEER, it is impracticable to follow the foregoing procedure exactly for any reason, modifications in the procedure shall be made as required and accepted by the ENGINEER. In any event the CONTRACTOR shall be responsible for the ultimate tightness of the pipe joints within the above leakage and pressure requirements.

END OF SECTION

SECTION 33 92 10 - STEEL PIPE, SPECIALS, AND FITTINGS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide steel pipe, specials, and fittings, complete and in place, in accordance with the Contract Documents.

B. A single pipe manufacturer shall be made responsible for furnishing steel pipe, specials, fittings, and appurtenances such as bolts and gaskets for the WORK.

1.2 CONTRACTOR SUBMITTALS

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

B. Furnish the following information with Shop Drawings:

1. Certified dimensional drawings of fittings and appurtenances.

2. Joint and pipe/fitting wall construction details which indicate the type and thickness of cylinder; the position, type, size, and area of reinforcement; coating and lining holdbacks, manufacturing tolerances, and other pertinent information required for the manufacture of the product.

3. Joint details where deep bell or butt strap joints are required for control of temperature stresses.

4. Details for elbows, wyes, tees, outlets, connections, test bulkheads, and nozzles or other specials that indicate amount and position of reinforcement.

5. Fittings and specials, showing proper reinforcement to withstand the internal pressure, both circumferential and longitudinal, and the external loading conditions as indicated.

6. Material lists and steel reinforcement schedules that describe materials to be utilized, including metallurgical, chemical, and physical test reports from each heat of steel to verify the steel conforms to the indicated requirements.

7. Line layout and marking diagrams which indicate the specific number of each pipe and fitting, the location of each pipe, the direction of each fitting in the completed line, and the following:

a. the pipe station and invert elevation at every change in grade or horizontal alignment

b. the station and invert elevation to which the bell end of each pipe will be laid

c. elements of curves and bends, both in horizontal and vertical alignment

d. the limits within each reach of restrained and/or welded joints or of concrete encasement

e. location and dimensional allocations for each indicated valve, fitting, and appurtenance

8. Welds

a. Submit full and complete information regarding location, type, size, and extent of welds.

b. The Shop Drawings shall distinguish between shop and field welds.

c. Shop Drawings shall indicate by welding symbols or sketches the details of the welded joints and the preparation of parent metal required to make them.

d. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

9. Joint design and details, including gasket data.

10. Harness joint details, including all bolts, couplings, gaskets, weld information, and hardware.

11. Drawings showing the location, design, and details of bulkheads for hydrostatic testing of the pipeline, and details for removal of test bulkheads and repair of the lining.

12. Details and locations of closures for length adjustment and for construction convenience.

13. Detail drawings indicating the type, number, and other pertinent details of the slings, strutting, and other methods proposed for pipe handling during manufacturing, transport, and installation.

C. Certifications

1. The CONTRACTOR shall furnish a certified affidavit of compliance for pipe and other products or materials in AWWA C200 - Steel Water Pipe 6 in and Larger, AWWA C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in and Larger-Shop Applied, AWWA C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 In Through 144 In, AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings, AWWA C209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipe, AWWA C210 - Liquid–Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines, AWWA C214 - Tape Coating Systems for the Exterior of Steel Water Pipelines, AWWA C215 - Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines, , AWWA C218 - Coating the Exterior of Aboveground Steel Water Pipelines and Fittings, AWWA C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe, AWWA C221 - Fabricated Steel Mechanical Slip-Type Expansion Joints and C222 - Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines and Fittings, and the following supplemental requirements:

a. physical and chemical properties of steel

b. hydrostatic test reports

c. results of production weld tests

d. sand, cement, and mortar tests

e. gasket tests

f. coating adhesion test

g. records of coating application

2. Performance and payment for sampling and testing necessary for certification are the CONTRACTOR's responsibility as part of the WORK.

D. Manufacturer’s Qualifications

1. Furnish a copy of manufacturer’s certification to ISO 9000, SPFA, or LRQA, and documentation of manufacturer’s experience in fabricating AWWA C200 pipe.

E. Design Calculations of Fittings and Specials

1. Furnish a copy of the design calculations for fittings and specials including miters, welds, and reinforcement, prior to manufacture of the pipe, fittings, and specials.

1.3 QUALITY ASSURANCE

A. Pipe Manufacturer Qualifications

1. The pipe manufacturer shall be certified to ISO 9000, the Steel Plate Fabricator’s Association (SPFA), or Lloyd’s Register Quality Assurance (LRQA), and shall be experienced in fabrication of AWWA C200 pipe of similar diameters, lengths, and wall thickness to this WORK.

2. Experience shall be in the production facilities and personnel, not the name of the company that owns the production facility or employs the personnel.

B. Inspection

1. Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of AWWA C200, C205, and C214, C218, and C222, as supplemented by the indicated requirements.

2. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing start date not less than 14 Days prior to the start of any phase of the pipe manufacture.

C. Tests

1. Except as indicated otherwise, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of AWWA C200, C205, and C214 as follows and as applicable:

a. Joint gaskets shall be tested in accordance with AWWA C200.

b. Shop Tests

1) After the joint configuration is completed and prior to lining with cement mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 75 percent of the yield strength of the steel.

2) The test pressure shall be held for 2 minutes and the pipe visually inspected to confirm that welds are sound and leak-free.

c. In addition to the tests required in AWWA C200, weld tests shall be conducted on each 5,000-feet of production welds and at any other times there is a change in the grade of steel, welding procedure, or welding equipment.

d. Fittings fabricated from straight pipe previously passing a hydrostatic test need not have an additional hydrostatic test, provided that the welds are tested by nondestructive means and are demonstrated to be sound.

D. Shop Testing of Steel Plate Specials

1. If any special has been fabricated from straight pipe not previously tested and is of the type listed below, the special shall be hydrostatically tested with a pressure equal to 1-1/2 times the design working pressure: bends, wyes, crosses, tees with side outlet diameter greater than 30 percent of the main pipe diameter, and manifolds.

2. Specials not required to be hydrostatically tested shall be tested by liquid dye penetrant inspection method in accordance with ASTM E 165 - Standard Test Methods for Liquid Penetrant Examination, Method A, or the magnetic particle method in ASME Section VIII, Division 1, Appendix VI.

3. Reinforcing plates shall be tested by the solution method using approximately 40 psig air pressure introduced between the plates through a threaded test hole; the test hole shall be properly plugged following successful testing.

4. Weld Imperfections

a. Weld defects, cracks, leaks, distortion, or signs of distress during testing shall require corrective measures.

b. Weld defects shall be gouged out and re-welded.

c. After corrections, the special shall be retested.

5. Test Heads

a. Where welded test heads or bulkheads are used, extra length shall be provided to each opening of the special.

b. After the removal of each test head, the special shall be trimmed back to the design points with finished plate edges ground smooth, straight, and prepared for the field joint.

6. Testing shall be performed before joints have been coated or lined.

7. Ultrasonic examination shall be performed in accordance with the following:

a. Steel plate that will be in welded joints or welded stiffener elements shall be examined ultrasonically for laminar discontinuities where both of the following conditions exist:

1) any plate in the welded joint has a thickness exceeding 1/2 inch

2) any plate in the welded joint is subject to transverse tensile stress through its thickness during the welding or service

b. Ultrasonic examination may be waived where joints are designated to minimize potential laminar tearing.

c. The ultrasonic examination shall be in accordance with ASTM A 578 - Straight Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications, with a Level I acceptance standard.

8. Plates that are not in conformance with the acceptance criteria in ASTM A 578 may be used in the WORK if the areas that contain the discontinuities are a distance at least 4 times the greatest dimension of the discontinuity away from the weld joint.

E. The CONTRACTOR shall be responsible for performing and paying for the indicated material tests.

F. The ENGINEER has the right to witness testing conducted by the CONTRACTOR, provided that the CONTRACTOR's schedule is not delayed for the convenience of the ENGINEER.

G. Additional Testing

1. In addition to those tests specifically required, the ENGINEER may request additional samples of any material including mortar lining and coating for testing by the OWNER.

2. The additional samples shall be furnished as part of the WORK.

H. Field Testing

1. Field testing shall be in accordance with the requirements of Section 01 74 30 – Pressure Pipe Testing and Disinfection.

I. Welding Requirements

1. Welding procedures used to fabricate and install pipe shall be prequalified under the provisions of ANSI/AWS D1.1 - Structural Welding Code-Steel, or the ASME Boiler and Pressure Vessel Code, Section 9.

2. Welding procedures shall be required for longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.

J. Welder Qualifications

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

2. Welders shall be qualified under the provisions of ANSI/AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9 by an independent local, approved testing agency not more than 6 months prior to commencing WORK on the pipeline.

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

PART 2 -- PRODUCTS

2.1 GENERAL

A. Lined and coated steel pipe and specials shall conform to AWWA C200, C205, C209, C210, C213, C214, C218, and C222, subject to the following supplemental requirements:

1. The pipe, specials, and fittings shall be of the diameter and class indicated and shall be provided complete with rubber gaskets or welded joints as indicated.

2. For pipe, specials, and fittings 14-inch diameter and larger, the nominal inside diameter after lining shall be not less than the indicated diameter, allowing for tolerances according to AWWA C200 and C205.

3. Pipe, specials, and fittings smaller than 14-inch diameter may be furnished in standard outside diameters.

4. When indicated as a minimum, wall thickness tolerance shall be as allowed by AWWA C200 or the ASTM nominal sheet or plate tolerance, whichever is less.

B. Markings

1. The manufacturer shall legibly mark pipe, specials, and fittings in accordance with the laying schedule and marking diagram.

2. Each pipe, special, and fitting shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation.

3. Each pipe, fitting, and special shall be marked at each end with top field centerline.

C. Handling and Storage

1. The pipe, specials, and fittings shall be handled by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating and exterior.

2. The use of chains, hooks, or other equipment that might injure the pipe coating or exterior will not be permitted.

3. Stockpiled pipe, specials, and fittings shall be supported on padded skids, sand or earth berms free of rock exceeding 3 inches in diameter, sand bags, or suitable means so that the pipe including coating and lining coating will not be damaged.

4. Pipe, specials, and fittings shall not be rolled and shall be secured to prevent accidental rolling.

D. The CONTRACTOR shall replace or repair damaged pipe, specials, and fittings.

E. Strutting

1. Adequate strutting shall be provided on specials, fittings, and straight pipe in order to avoid damage to the pipe, specials, and fittings during handling, storage, hauling, and installation.

2. For mortar-lined steel pipe, specials, or fittings the following requirements shall apply:

a. The strutting shall be placed as soon as practicable after the mortar lining has been applied and shall remain in place while the pipe, special, or fitting is loaded, transported, unloaded, installed, and backfilled at the Site.

b. The strutting materials, size, and spacing shall be adequate to support the earth backfill plus any greater loads that may be imposed by the backfilling and compaction equipment.

c. Any pipe, special, or fitting damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.

F. Laying Length

1. The maximum pipe laying length shall be 48 feet, with shorter lengths to be provided as indicated and required.

G. Lining

1. The pipe, specials, and fittings shall have smooth, dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.

H. Closures and Correction Pieces

1. Closures and correction pieces shall be provided as required such that closures may be made due to different headings in the pipe laying operation and such that corrections may be made to adjust the pipe laying to conform to the indicated pipe stationing.

2.2 MATERIALS

A. Mortar

1. Materials for mortar shall conform to the requirements of AWWA C205; provided that cement for mortar coating shall be Type V, and mortar lining shall be Type II or V.

2. Cement in mortar lining and coating shall not originate from kilns that burn metal-rich hazardous waste fuel, nor shall a fly ash or pozzolan be used as a cement replacement.

3. Admixtures shall contain no calcium chloride.

B. Steel for Cylinder and Fittings

1. Pipe, specials, and fittings manufactured under AWWA C200 shall satisfy the following requirements:

    a. minimum yield strength of steel: 42,000 psi

    b. manufactured by a continuous casting process

    c. fully kilned

    d. fine grain practice

    e. maximum carbon content: 0.25 percent

    f. maximum sulfur content: 0.015 percent

    g. minimum elongation: 22 percent in a 2-inch gauge length

    h. in accordance with one of the following Standards:

        1) ASTM A 1011 - Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

        2) ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates

        3) ASTM A 572 - High Strength Low-Alloy Columbium-Vanadium Structural Steel

        4) ASTM A 1018 - Steel, Sheet and Strip, Heavy Thickness Coils, Hot-Rolled Carbon, Structural, High-Strength Low-Alloy Columbium or Vanadium, and High-Strength Low-Alloy with Improved Formability

2. Testing

    a. Steel equal to or greater than 1/2 inch thick used in fabricating pipe shall be tested for notch toughness using the Charpy V-Notch test in accordance with ASTM A 370 - Test Methods and Definitions for Mechanical Testing of Steel Products.

    b. The frequency of testing shall be one impact test (set of 3 specimens - transverse, not longitudinal) for each coil used in manufacturing the pipe.

    c. The testing frequency for sheets and plates shall be one impact test (set of 3 specimens) for each 200 tons of product.

    d. The steel shall withstand a minimum impact of 25 ft-lb at a temperature of 30 degrees F.

C. Prefabricated Multi-layer Cold-Applied Tape Coating

1. The coating system for straight line pipe shall be in accordance with AWWA C214

2.3 DESIGN OF PIPE

A. General

1. The pipe shall be suitable to transmit raw water under the indicated conditions.

2. The steel pipe shall have joints as indicated on the Drawings. All joints and harnesses shall be restrained to resist thrust forces resulting from the Internal Design Pressure.

3. The pipe shall consist of a steel cylinder, shop-lined with Portland cement mortar and an exterior coating of cement mortar in accordance with C205.

B. All buried steel pipe, fittings, specials, and appurtenances shall be designed to the following standards:

1. Diameter: As shown on the Drawings

2. Standard Pipe Segment Length: 20 feet

3. Internal Design Pressure (Operating + Surge Pressure), Minimum: 150 psig

4. Anticipated Operating Pressures: 10 to 20 psig

5. Transient Pressure: 0 psig

6. Test Pressure: 150 psig

7. Design Cover (maximum): 23 feet.

8. AASHTO HS20 truck loading.

C. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements as indicated and, except as indicated, shall conform to AWWA C200.

D. Pipe Dimensions

1. The pipe shall be of the diameter and minimum wall thickness indicated.

E. Fitting Dimensions

1. Fittings shall be of the diameter and class indicated.

F. Joint Design

1. Butt-strap joints shall be used only where required for closures or where indicated.

2. Unless indicated otherwise, the standard field joint for steel pipe shall be as indicated in the following table:

Pipe Diameter	Application	Joint Type
42 inches and less	non-restrained areas	Not Applicable
	restrained areas	lap-welded joint
	closures, restrained	butt strap joint

Pipe Diameter	Application	Joint Type
greater than 42 inches	non-restrained areas	Not Applicable
	restrained areas	lap-welded joint
	closures, restrained	butt strap joint

G. Lap Joints for Field Welding

1. Lap joints prepared for field welding shall be in accordance with AWWA C200.

2. The method used to form, shape, and size bell ends shall be such that the physical properties of the steel are not substantially altered.

3. Unless otherwise approved by the ENGINEER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.

4. Faying surfaces of the bell and spigot shall be essentially parallel except for mitered bells, but the bell slope shall not vary more than 2 degrees from the longitudinal axis of the pipe.

H. Field Joints

1. The joints shall have the same or higher pressure rating as the adjoining pipe.

2. The clearance between faying surfaces shall be less than 1/8 inch.

I. Restrained Joints

1. Restrained joints shall be located where indicated

2. Restrained joints shall be field-welded joints, either single, or inside and outside lap-weld, or butt-weld, or butt-straps as indicated.

3. Designs shall include stresses created by the greater of:

   a. a temperature differential of 40 degrees F plus Poisson's effect in combination with hoop stress, or;

   b. thrust due to bulkheads, bends, reducers, and line valves resulting from working pressure in combination with hoop stress.

4. For field-welded joints, design stresses shall not exceed 50 percent of the specified minimum yield strength of the grade of steel utilized, or 21,000 psi, whichever is less, for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint

2.4 SPECIALS AND FITTINGS

A. Design

1. Except as otherwise indicated, materials, fabrication and shop testing of specials and fittings shall conform to the requirements stated above for pipe and shall conform to the dimensions of AWWA C208.

2. The minimum thickness of plate for pipe from which specials are to be fabricated shall be the greatest of those determined by the following 3 criteria:

   a. Working and Transient Pressure Design

$$T = \frac{P_w D/2}{Y/S_w} \qquad T = \frac{P_t D/2}{Y/S_t}$$

   Where:

T	=	Steel cylinder thickness in inches
D	=	Outside diameter of steel cylinder in inches
P_w	=	Design working pressure in psi
P_t	=	Design transient pressure in psi
Y	=	Specified minimum yield point of steel in psi
S_w	=	Safety factor of 2.5 at design working pressure
S_t	=	Safety factor at design transient pressure; for elbows 1.875 and 2.0 for other specials

   b. Mainline Pipe Thickness: Plate thickness for specials shall be not less than the adjacent mainline pipe.

   c. Minimum Thickness Based on Pipe Diameter

Nominal Pipe Diameter, inches	Pipe Manifolds Piping Above Ground Piping Structures
24 and under	3/16 inch
25 to 48	1/4 inch
over 48	5/16 inch

B. Specials

1. Specials installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi.

2. Design shall be in accordance with the provisions of Chapter 7 of AWWA Manual M11.

C. Deflections and Angles

1. Moderate deflections and long radius curves may be constructed by means of beveled joint rings, by pulling standard joints, by using short lengths or pipe, or a combination of these methods provided that pulled joints shall not be used in combination with bevels.

2. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint.

3. Bevels shall be provided on the bell ends.

4. Mitering of the spigot ends will not be accepted.

5. The maximum allowable angle for pulled joints shall be in accordance with the manufacturer's recommendations, or the angle which results from a 3/4-inch pull-out from normal joint closure, whichever is less.

6. Horizontal deflections or fabricated angles shall fall on the alignment.

7. In locations where underground obstructions may be encountered, the chord produced by deflecting the pipe shall be no further than 6 inches from the indicated alignment.

8. Vertical Deflections

    a. Vertical deflections shall fall on the alignment and shall be at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures.

    b. The pipe angle points shall match the indicated angle points.

D. Outlets, Tees, Wyes, Crosses, and Nozzles

1. Outlets 12 inches and smaller may be fabricated from Schedule 30 or heavier steel pipe in the standard outside diameters, that is, 12-3/4-inch, 10-3/4-inch, 8-5/8-inch, 6-5/8-inch, and 4-1/2-inch.

2. The minimum plate thickness for reinforcements shall be 10-gauge.

3. The outlet reinforcement design shall be in accordance with the procedures given in Chapter 13 of AWWA Manual M11, and the design pressures and factors of safety indicated above.

4. In lieu of saddle or wrapper reinforcement as provided by the design procedure in Manual M11, pipe or specials with outlets may be fabricated entirely of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.

5. Where Manual M11 requires the design procedure for crotch plate reinforcement, such reinforcement shall be provided.

6. Reinforcing Plates

    a. Outlets shall be fabricated such that there is always at least a 12-inch distance between the outer edge of the reinforcing plate and any field-welded joints.

    b. For outlets without reinforcing plates, outlets shall penetrate the steel cylinders so that there is at least a 12-inch clearance between the outlet and any field-welded joints.

7. Tees, wyes, crosses, elbows, and manifolds shall be fabricated such that the outlet clearances and reinforcing plates from any weld joints are a minimum of 5 times cylinder thickness or 2 inches, whichever is greater.

8. Longitudinal weld joints in adjacent cylinder sections shall be oriented such that there is a minimum offset of 5 times cylinder thickness or 2 inches, whichever is greater.

9. Reinforcement

    a. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M11.

    b. Reinforcement shall be designed for the design pressure indicated and shall be as indicated.

10. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe.

11. Unless otherwise indicated, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees.

E. Steel welding fittings shall conform to ASTM A 234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

F. Ends for Mechanical-Type Couplings

1. Except as otherwise indicated, where mechanical-type couplings are indicated the ends of pipe shall be banded with Type C collared ends using double fillet welds.

2. Where pipe 12-inch and smaller is furnished in standard schedule thickness and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.

2.5 CEMENT-MORTAR LINING

A. Cement-Mortar Lining for Shop Application

1. Unless indicated otherwise, interior surfaces of pipe, specials, and fittings shall be cleaned and lined in the shop with cement mortar lining applied centrifugally in conformity with AWWA C205.

2. During the lining operation and thereafter, the pipe, specials, and fittings shall be maintained in a round condition by suitable bracing or strutting.

3. The lining machines shall be of a type that has been used successfully for similar WORK.

4. Every precaution shall be taken to prevent damage to the lining.

5. If the lining is damaged or found defective at the Site, the damaged or unsatisfactory portions shall be replaced with lining conforming to the indicated requirements.

B. The minimum lining thickness and tolerance shall be in accordance with AWWA C205.

C. Field Joints

1. The pipe shall be left bare as indicated where field joints occur.

2. Ends of the linings shall be left square and uniform.

3. Feathered or uneven edges will not be accepted.

D. Defective Linings

1. Defective linings, as determined by the ENGINEER, shall be removed from the pipe wall and shall be replaced to the full thickness required.

2. Defective linings shall be cut back to a square shoulder in order to avoid feather-edged joints.

E. The progress of the application of mortar lining shall be regulated in order that handwork, including the repair of defective areas, is cured in accordance with the provisions of AWWA C205.

F. Cement mortar for patching shall be the same materials as the mortar for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.

G. Hand-Applied Linings

1. Specials and fittings that cannot be mechanically lined and coated shall be lined and coated by hand-application using the same materials as used for the pipe and in accordance with the applicable AWWA or ASTM standards and as indicated.

2. Coating and lining applied in this manner shall provide protection equal to that for the pipe.

3. Fittings may be fabricated from pipe that has been mechanically lined and/or coated.

4. Areas of lining and coating that have been damaged by such fabrication shall be repaired by hand-application.

H. Protection of Pipe Lining/Interior

1. For pipe, specials, and fittings with plant-applied cement-mortar linings, the CONTRACTOR shall provide a 12-mil polyethylene sheet or other suitable bulkhead on the ends of the pipe and on each opening to prevent the lining from drying out.

2. Bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

2.6 EXTERIOR COATING OF PIPE

A. Exterior Coating of Exposed Piping

1. The exterior surfaces of pipe, specials, and fittings that will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of primer compatible with the finish coating required by Section 09 96 00 – Protective Coating.

B. Exterior Coating of Buried Piping

1. Pipe for buried service, including bumped heads, shall be coated with a minimum one-inch thickness of reinforced cement-mortar coating.

2. Unless otherwise indicated, exterior surfaces of pipe or fittings passing through structure walls shall be cement-mortar coated from the center of the wall or from the wall flange to the end of the underground portion of pipe or fitting.

3. The coating shall be reinforced with a spiral wire reinforcement or welded wire fabric in accordance with AWWA C205.

4. The welded wire fabric shall be securely fastened to the pipe with welded clips or strips of steel.

5. The wire shall be spaced 2 inches on centers and shall extend circumferentially around the pipe.

6. The ends of reinforcement strips shall be lapped 4 inches, and the free ends shall be tied or looped to assure continuity of the reinforcement.

C. Flexible Coatings

1. Flexible coatings shall conform to Section 09 96 12 – Polyethylene Tape Coating

2. The CONTRACTOR shall select one flexible coating system for all piping in the Contract; the use of both systems in any combination will not be accepted.

3. Flexible coating systems shall include a cement mortar protective overcoat (rock shield) in accordance with Sections 09 96 12 – Polyethylene Tape Coating and 09 96 05 – Extruded Polyolefin Coating.

2.7 PIPE APPURTENANCES

A. Pipe appurtenances shall be in accordance with the requirements as indicated.

B. Access manholes with covers shall be as indicated, installed during fabrication and not in the field.

C. Threaded outlets shall be forged steel suitable for 3000-psi service, and shall be as manufactured by **Vogt**, or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION OF PIPE

A. Handling and Storage

1. Pipe, specials, and fittings shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, and impact shocks and free fall.

2. Pipe, specials, and fittings shall not be placed directly on rough ground but shall be supported in a manner that will protect the pipe against injury whenever stored at the Site or elsewhere.

3. Pipe, specials, and fittings shall be handled and stored at the Site in accordance with the requirements indicated in Part 2, above.

4. No pipe shall be installed when the lining or coating, or interior or exterior surfaces show cracks that may be harmful as determined by the ENGINEER.

5. Such damaged lining and coating, and interior and exterior surfaces shall be repaired or a new undamaged pipe, special, or fitting shall be provided.

B. Pipe damaged prior to Substantial Completion shall be repaired or replaced.

C. The CONTRACTOR shall inspect each pipe, special, and fitting for damage.

D. The CONTRACTOR shall remove or smooth out any burrs, gouges, weld splatter, or other small defects prior to laying the pipe, special, or fitting.

E. Cleaning

1. Before the placement of pipe, specials, or fittings in the trench, each shall be thoroughly cleaned of any foreign substance that may have collected thereon and shall be kept clean thereafter.

2. For this purpose, the openings of pipes, specials, and fittings in the trench shall be closed during any interruption to the WORK.

F. Placement

1. Pipe, specials, and fittings shall be laid directly on the imported bedding material.

2. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe, special, or fitting.

3. Excavations shall be made as needed to facilitate removal of handling devices after the item has been laid.

4. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings.

5. Excavation outside the normal trench section shall be made at field joints as needed to permit adequate access to the joints for field connection operations and for application of coating on field joints.

6. Except for short runs that may be permitted by the ENGINEER, pipes shall be laid uphill if on grades exceeding 10 percent.

7. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement.

8. Bends shall be installed as indicated.

G. Installation Tolerances

1. Each section of pipe, special, or fitting shall be laid in the order and position on the laying diagram and in accordance with the following:

a. Each section of pipe, special, or fitting having a nominal diameter less than 48 inches shall be laid to line and grade, within plus or minus 2 inches horizontal deviation and plus or minus one inch vertical deviation.

b. Each section of pipe, special, or fitting having nominal diameter 48 inches and larger shall be laid to line and grade, within plus or minus 5 percent of diameter horizontal deviation and plus or minus 2.5 percent of diameter vertical deviation.

c. In addition to the horizontal and vertical tolerances above, the pipe shall be laid so that no high or low points other than those on the laying diagram are introduced.

d. After installation, the pipe, specials, and fittings shall not show deflection greater than:

1) mortar-lined and mortar-coated pipe, specials, and fittings: 1.5 percent

2) mortar-lined and flexible-coated pipe, specials, and fittings: 2.25 percent

3) flexible-lined and flexible-coated or bare pipe, specials, and fittings: 3.0 percent

e. The allowable deflection shall be based on the design inside diameter.

H. Test Section

1. At the beginning of pipe laying operations, the CONTRACTOR shall perform a test section to demonstrate that the methods and materials to be used will satisfy the pipe zone backfill compaction and pipe deflection criteria.

2. The maximum length of the test section shall be 500 feet.

3. The CONTRACTOR shall not proceed with production pipe laying beyond the test section without the ENGINEER's approval.

4. The entire test section length that does not comply with the Contract Documents shall be reworked as necessary to comply.

5. The ENGINEER will observe construction of the test section.

6. The OWNER will take measurements and keep records for quality assurance purposes.

7. Any change in means, methods, and trench conditions, including excavation, bedding, and pipe zone materials, in situ soils, water conditions, and backfill and compaction methods shall require another successful test section before additional production pipe installation.

I. Changes in Alignment and/or Grade

1. Where necessary to raise or lower the pipe, specials, or fittings due to unforeseen obstructions or other causes, the ENGINEER may change the alignment and/or the grade.

2. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings, although in no case shall the deflection in a joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer.

3. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint.

4. In each case the joint opening, before finishing with the protective mortar inside the pipe, shall be the controlling factor.

J. Struts

1. Struts shall be left in place until backfilling operations have been completed.

2. A laboratory selected and paid by the OWNER may monitor pipe deflection by measuring pipe inside diameter before struts are removed and 24 hours after struts are removed.

3. Pipe deflection tolerances shall be observed and verified after strut removal.

4. After the backfill has been placed, the struts shall be removed and shall remain the property of the CONTRACTOR.

K. Cold Weather Protection

1. No pipe, special, or fitting shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation.

2. No pipe, special, or fitting shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.

L. Pipe, Specials, and Fitting Protection

1. The openings of pipe, specials, and fittings with shop-applied mortar lining shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water, or any undesirable substance.

2. The bulkheads shall be designed to prevent the drying out of the interior of the pipe, specials, and fittings.

3. The CONTRACTOR shall introduce water into the pipe to keep the mortar moist if moisture has been lost due to damaged bulkheads.

4. Means shall be provided to prevent the pipe from floating due to water in the trench from any source.

5. Pipe that has floated shall be repaired, including restoration to original condition and profile.

M. Pipe Cleanup

1. As pipe laying progresses, the CONTRACTOR shall keep the pipe interior free of debris.

2. The CONTRACTOR shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying, pointing of joints, and any necessary interior repairs prior to testing and disinfecting of the completed pipeline.

3.2 RUBBER GASKETED JOINTS

A. Rubber Gasketed Joints

1. Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with a non-toxic vegetable-based lubricant shall be placed in the spigot groove.

2. The lubricant shall be a compound listed as in compliance with NSF Standard 61.

3. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring.

4. The bell of the pipe already in place shall be carefully cleaned and lubricated with the vegetable-based lubricant.

5. The spigot of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position.

6. Tilting of the pipe to insert the spigot into the bell will not be permitted.

7. After the pipe units have been joined, a feeler gauge shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket.

8. If the gasket cannot be "felt" all around, the joint shall be disassembled and the joint shall be reassembled with a new gasket.

B. Double Gasket Lap Joints

1. Double gasket lap joints shall be air-tested by shop drilling and tapping for 1/8-inch or 1/4-inch national pipe thread in the lap or bell end of the pipe.

2. Apply 40 psig of air or other satisfactory gas into the connection between the 2 gaskets.

3. Test pressure shall be measured with a minimum 4-inch diameter pressure gauge with a range no greater than 0 to 100 psig.

4. The air test shall consist of holding the test pressure undiminished for 5 minutes.

5. If the test fails, the joint shall be disassembled and reassembled with new gaskets.

6. After the repair is made, the joint shall be checked by repeating the original test procedure.

7. After a successful test, close the threaded opening with a pipe plug or by welding.

3.3 WELDED JOINTS

A. General

1. Prior to beginning the welding procedure, any tack welds used to position the pipe during laying shall be removed.

2. Any annular space between the faying surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means.

3. Where more than one pass is required, each pass except the first and final ones shall be peened to relieve shrinkage stresses, and dirt, slag, and flux shall be removed before the succeeding bead is applied.

4. Prior to butt welding, the pipe and joint shall be properly positioned in the trench using line up clamps so that, in the finished joint, the abutting pipe sections shall not be misaligned more than 1/16 inch.

5. Unless double fillet welds are indicated, field welded lap joints may, at the CONTRACTOR'S option, be made on either the inside or the outside of the pipe. The CONTRACTOR shall take measures to ensure that any tape coat and shrink sleeve on exterior of the pipe is not damaged during this process.

6. Field welded joints shall be in accordance with AWWA C206 - Field Welding of Steel Water Pipe.

7. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.

8. Butt straps shall be as indicated.

9. A heat resistant shield shall be draped over at least 24-inches of coating beyond the holdback on both sides of the weld during welding to avoid damage to the coating by hot weld splatter.

10. Welding grounds shall not be attached to the coated part of the pipe.

B. Backfilling

1. After the pipe and joint are properly positioned in the trench, the length of pipe between joints shall be backfilled to at least one foot above the top of the pipe.

2. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.

C. Temperature Stresses

1. To control temperature stresses, the unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed.

2. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe.

3. Shading of the pipe joints need not be performed when the ambient air temperature is below 45 degrees F.

D. Shrinkage Control Joints

1. At intervals not exceeding 250 feet along welded reaches of the pipeline and at the first regular lap-welded field joints outside concrete encasements and structures, the pipe shall be laid with an initial lap of not less than one inch greater than the minimum lap dimension.

2. The welding of each such shrinkage control joint shall be performed when the temperature is approximately the lowest during the 24 hour day, after at least 250 feet of pipe have been laid and the joints have been welded ahead of and in back of the shrinkage control joint, and after backfill has been completed to at least one foot above the top of the pipe ahead of and in back of the shrinkage control joint.

3. Where shrinkage control joints occur in a traveled roadway or other inconvenient location, the location of the shrinkage control joint may be adjusted, as acceptable to the ENGINEER.

E. Inspection of Field-Welded Joints

1. An independent testing laboratory acceptable to the ENGINEER but paid by the CONTRACTOR shall inspect the joints.

2. Inspection shall be as soon as practicable after the welds are completed.

3. Fillet welds shall be tested by the Magnetic Particle Inspection Method in accordance with ASME Section VIII, Division 1, Appendix VI.

4. Double-Welded Lap Joints

a. Double-welded lap joints shall be air-tested by shop drilling and tapping for 1/8-inch or 1/4-inch national pipe thread in the lap or bell end of the pipe.

b. Apply 40 psig of air or other satisfactory gas into the connection between the 2 fillet welds.

c. Test pressure shall be measured with a minimum 4-inch diameter pressure gauge with a range no greater than 0 to 100 psig.

d. The air test shall consist of holding the test pressure undiminished for 5 minutes.

e. If the air test fails, paint the welds with a soap solution and mark any leaks indicated by the escaping gas bubbles.

f. Leaking portions of the welds or defective welds shall be removed and re-welded.

g. The amount of material removed shall be limited to that required to correct the defect.

h. After the repair is made, the joint shall be checked by repeating the original test procedure.

i. Close the threaded openings with pipe plugs or by welding.

5. Butt welds shall be inspected by radiographic methods in accordance with API Standard 1104.

F. Following tests of the joint, the exterior joint spaces shall be coated as indicated, after which backfilling may be completed.

G. Repair of Welds

1. Defective welds shall be repaired by the CONTRACTOR to meet the indicated requirements.

2. Defects in welds or defective welds shall be removed, and that section of the joint shall then be re-welded.

3. Only sufficient removal of defective material that is necessary to correct the defect shall be required.

4. After the repair is made, the joint shall be checked by repeating the original test procedure.

5. Welds deficient in size shall be repaired by adding weld metal.

3.4 JOINT COATING AND LINING

A. General

1. The interior and exterior joint recesses shall be thoroughly wiped clean.

2. Remove water, loose scale, dirt, and other foreign material from the inside surface of the pipe.

B. Joint Coating of Shop-Applied Tape-Coated Pipe: Coat the joints in accordance with the requirements of Section 09 96 12 – Polyethylene Tape Coating.

C. Testing

1. The ENGINEER will test each joint with an electrical detector, furnished by the CONTRACTOR and capable of at least a 12,000 volt output.

2. The tests will be performed using 6,000 to 7,000 volts.

3. The CONTRACTOR shall repair any holidays.

4. Re-Testing

a. When a visual inspection indicates that a portion of the coating system has sustained physical damage, the CONTRACTOR shall perform an electrical holiday test of 6,000 to 7,000 volts.

b. When the test indicates no holiday, a notation shall be applied to the area indicating the test is satisfactory.

D. Coating Repair

1. Mortar-Coated Pipe: Perform coating repairs on mortar-coated pipe in accordance with the requirements of AWWA C205.

2. Tape-Coated Pipe

    a. Perform coating repairs on tape-coated pipe tape and primer in accordance with the requirements of AWWA C209.

    b. If the holiday re-test indicates a holiday still exists after re-testing, the inner wrap shall be exposed and the exposed area shall be wiped clean with xylol solvent or equal, and the area shall be coated with tape primer.

    c. A patch of 35-mil thick cold-applied tape of sufficient size to cover the damaged area plus a minimum lap of 2-inches shall then be applied.

    d. The patched area shall again be tested for holidays.

    e. If none are detected, a second layer of 35-mil thick tape shall then be applied over the first patch, overlapping the first layer a minimum of 2 inches.

E. Coating of Fittings and Specials: Fittings and specials shall be coated in accordance with Section 09 96 12 – Polyethylene Tape Coating.

F. Joint Lining

1. After the backfill has been completed to final grade, the interior joint recess shall be filled with mortar.

2. Materials of construction for mortar shall be in accordance with the requirements of AWWA C602.

3. The mortar shall be tightly packed into the joint recess and troweled flush with the interior surface, and excess shall be removed.

4. At no point shall there be an indentation or projection of the mortar exceeding 1/16 inch.

5. With pipe smaller than 24-inch in diameter, before the spigot is inserted into the bell, the bell shall be daubed with mortar.

6. The joint shall be completed and excess mortar on the inside of the joint shall be swabbed out.

3.5 INSTALLATION OF PIPE APPURTENANCES

A. Protection of Appurtenances: Where the joining pipe is tape-coated, buried appurtenances shall be coated with cold-applied tape in accordance with Section 09 96 12 – Polyethylene Tape Coating.

B. Installation of Valves

1. Valves shall be handled in a manner to prevent any injury or damage to the valve or any part of it.

2. Joints shall be thoroughly cleaned and prepared prior to installation.

3. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to verify proper operation.

4. Valves shall be installed so that the valve stems are plumb and in the location indicated.

5. Buried valves and flanges shall be coated and protected in accordance with Section 09 96 00 – Protective Coating.

C. Installation of Flanged Joints

1. Before the joint is assembled, the flange faces shall be thoroughly cleaned of foreign material with a power wire brush.

2. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges.

3. Bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable and calibrated torque wrench.

4. Clamping torque shall be applied to the nuts only.

5. Full-face reinforced rubber gaskets shall be applied to the inside face of blind flanges with adhesive.

D. Insulated Joints

1. Insulated joints and appurtenant features shall be provided as indicated.

2. The CONTRACTOR shall exercise special care when installing these joints in order to prevent electrical conductivity across the joint.

3. After the insulated joint is completed, an electrical resistance test shall be performed by the CONTRACTOR.

4. If the resistance test indicates a short circuit, the CONTRACTOR shall remove the insulating units to inspect for damage, replace all damaged portions, and reassemble the insulating joint.

5. The insulated joint shall then be retested to assure proper insulation.

E. Flexible Coupled Joints

1. When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings, and gaskets are clean and free of dirt and foreign matter, with special attention given to the contact surfaces of the pipe, gaskets, and couplings.

2. The couplings shall be assembled and installed in conformance with the recommendations and instructions of the coupling manufacturer.

F. Bolting

1. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer.

2. Coupling bolts shall be tightened in such a manner as to secure a uniform annular space between the follower rings and the body of the pipe.

3. Bolts shall be tightened approximately the same amount.

4. Diametrically opposite bolts shall be tightened progressively and evenly.

5. Final tightening shall be performed with a suitable and calibrated torque wrench set for the torque recommended by the coupling manufacturer.

6. Clamping torque shall be applied to the nut only.

3.6 CORROSION CONTROL

A. Joint Bonding/Electrolysis Test Stations

1. Except where otherwise indicated, joints shall be bonded.

2. The pipe shall be cleaned to bare bright metal at the point where the bond is to be installed.

3. Electrolysis test stations shall be installed where indicated.

END OF SECTION

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SECTION 33 92 20 - DUCTILE IRON PIPING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide ductile iron pipe and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

AWWA C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in for Water
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C116	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast for Water
AWWA C153	Ductile-Iron Compact Fittings. for Water Service
AWWA C600	Installation of Ductile Iron Water Mains and Their Appurtenances
AWWA C606	Grooved and Shouldered Joints
ASTM C 150	Portland Cement

1.3 CONTRACTOR SUBMITTALS

A. Furnish Submittals in accordance with Section 01 33 00 - Contractor Submittals and the following supplemental requirements:

B. Shop Drawings

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

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

and bends, both in horizontal and vertical alignment; and the limits of each reach of restrained joints, or of concrete encasement.

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

1. Physical and chemical properties.

2. Hydrostatic test reports.

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

1.4 QUALITY ASSURANCE

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

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

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

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

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

PART 2 -- PRODUCTS

2.1 PIPE GENERAL

A. Mortar-lined and polyethylene-wrapped ductile iron pipe shall conform to AWWA C151, C104, and C105, subject to the supplemental requirements in this Section. The pipe shall be of the diameter and class indicated, shall be provided complete with rubber gaskets, specials, and fittings as required under the Contract Documents.

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

C. Handling and Storage: The pipe shall be handled as a minimum at the 1/3 points by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment that

might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be supported on padded skids, sand or earth berms free of rock exceeding 3-inches diameter, sand bags, or suitable means so that the coating will not be damaged. The pipe shall not be rolled and shall be secured to prevent accidental rolling

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

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

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

2.2 SPECIALS AND FITTINGS

A. Fittings for ductile iron pipe shall conform to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi. Ductile iron fittings larger than 48-inches shall conform to AWWA C153.

2.3 DESIGN OF PIPE

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

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

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

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

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

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

3. Restrained joints shall be **Flex-Ring or Lok-Ring** restrained joint by **American Ductile Iron Pipe**, **TR FLEX** or **HP Lok** restrained joint by **U.S. Pipe**, or equal.

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

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

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

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

d. The devices shall be **MegaLug Model 1100** as manufactured by **EBAA Iron** or equal.

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

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

2.4 CEMENT-MORTAR LINING

A. Cement-Mortar Lining for Shop Application: Except as otherwise provided herein, interior surfaces of ductile iron pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with AWWA C104. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found defective at the Site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications.

1. Cement: Cement for mortar lining shall conform to the requirements of AWWA C104; provided, that cement for mortar lining shall be Type II or V. Cement shall not originate from kilns that burn metal-rich hazardous waste fuel, nor shall a fly ash or pozzolan be used as a cement replacement.

B. The minimum lining thickness shall be as follows:

Nominal Pipe Diameter, inches	Minimum Lining Thickness, inches
3 - 12	1/16
14 - 24	3/32
30 - 64	1/8

C. Protection of Pipe Lining/Interior**:** Shop-applied cement mortar lining shall be given a seal coat of asphaltic material in conformance with AWWA C104.

2.5 EXTERIOR PROTECTION OF PIPE

A. Exterior Coating of Buried Piping: The exterior coating shall be an asphaltic coating approximately 1-mil thick.

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

PART 3 -- EXECUTION

3.1 INSTALLATION OF PIPE

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

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

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

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

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

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

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

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

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

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

3.2 RUBBER GASKETED JOINTS

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

3.3 POLYETHYLENE SLEEVE UNBONDED PROTECTION

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

3.4 INSTALLATION OF PIPE APPURTENANCES

A. Protection of Appurtenances: Where the joining pipe is dielectric-coated, buried appurtenances shall be coated in kind. Where pipe is encased in polyethylene sleeves, buried appurtenances shall be encased in polyethylene.

B. Installation of Valves: Valves shall be handled in a manner to prevent any injury or damage to any part of the valve. Joints shall be thoroughly cleaned and prepared prior to

installation. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to insure proper operation.

C. Valves shall be installed so that the valve stems are plumb and in the location indicated.

END OF SECTION

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SECTION 33 95 50 - PVC PRESSURE PIPE, RUBBER JOINTS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide polyvinyl chloride (PVC) pressure pipe, complete in place, as indicated in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

AWWA C104/A21.5 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water

AWWA C110/A21.10 Ductile-Iron and Gray-Iron Fittings 3-in Through 48-in for Water and Other Liquids

AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

AWWA C600 Installation of Ductile-Iron Water Mains and Appurtenances

AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe 4-in Through 60-in for Water Distribution

ASTM D 2584 Test Method for Ignition Loss of Cured Reinforced Resins

PPI Technical Report TR 3/4 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials

AWWA Manual M23 PVC Pipe - Design and Installation

1.3 CONTRACTOR SUBMITTALS

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

1. Shop Drawings

2. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals.

3. Shop Drawings: The CONTRACTOR shall submit Shop Drawings and laying diagrams of pipe, joints, bends, special fittings, and piping appurtenances.

4. Certificates: The CONTRACTOR shall submit manufacturer's certificate that pipe conforms to these specifications.

B. Testing

1. Test the materials used in the manufacture of the pipe in accordance with the requirements of this Section and the referenced standards, as applicable.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide PVC pressure pipe (4-inch through 12-inch) conforming to the applicable requirements of AWWA C900, and the requirements indicated in this Section.

B. AWWA C900 PVC used for water-tight drainage applications shall be DR 25, green color.

2.2 PIPE DESIGN CRITERIA

A. General

1. Design PVC pressure pipe wall thickness for internal pressure in accordance with the requirements of AWWA M23, as applicable, and the requirements indicated in this Section.

2.3 PIPE

A. Provide pipe of the indicated diameter and pressure class, complete with rubber gaskets.

B. Provide specials and fittings as indicated.

C. Joints

1. Joints for the buried PVC pipe shall be either an integral bell manufactured on the pipe or a separate coupling both employing a rubber ring joint.

2. Provide the bell and coupling of the same thickness as of the pipe barrel, or greater thickness.

D. Joint Deflection

1. Deflection at the joint shall not exceed 1.5 degrees or the maximum deflection commended by the manufacturer.

PART 3 -- EXECUTION

3.1 GENERAL

A. Perform laying, jointing, and testing for defects and leakage in the presence of the ENGINEER, and obtain the ENGINEER's approval before acceptance.

B. Material found to have defects will be rejected, and the CONTRACTOR shall promptly remove such defective materials from the Site.

C. Installation shall conform to the requirements of AWWA M23, instructions furnished by the pipe manufacturer, and to the supplementary requirements indicated herein.

D. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

3.2 HANDLING AND STORAGE

A. Handling

1. Carefully inspect pipe, fittings, and accessories before and after installation, and reject those found to be defective.

2. Pipe and fittings shall be free from fins and burrs.

3. Before being placed in position, clean the pipe, fittings, and accessories and maintain them in a clean condition.

4. Provide proper facilities for lowering sections of pipe into trenches.

5. Under no circumstances drop or dump pipe, fittings, or any other material into trenches.

B. Storage

1. Store pipe, if possible, at the Site in unit packages provided by the manufacturer.

2. Exercise caution to avoid compression damage or deformation to bell ends of the pipe.

3. Store pipe in such a way as to prevent sagging or bending, and protect pipe from exposure to direct sunlight by covering with an opaque material while permitting adequate air circulation above and around the pipe.

4. Store gaskets in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.3 TRENCHING AND BACKFILL

A. Trench excavation and backfill shall conform to the requirements of Section 31 30 00 – Earthwork.

3.4 INSTALLATION

A. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying.

B. Grade the pipe in straight lines, taking care to avoid the formation of any dips or low points.

C. Do not lay pipe when the conditions of trench or weather are unsuitable.

D. Use short lengths of pipe in and out of each rigid joint or rigid structure.

E. Replace piping that does not allow sufficient space for proper installation of jointing material with piping of proper dimensions.

F. Blocking or wedging between bells and spigots will not be accepted.

G. Install joints in accordance with the manufacturer's recommendations.

H. Keep trenches free of water until joints have been properly made.

I. The maximum combined deflection at couplings shall be in accordance with the manufacturer's recommendations.

J. Cutting

1. Cut the pipe by means of saws, power-driven abrasive wheels, or pipe cutters, which will produce a square cut.

2. Cuts by wedge-type roller cutters will not be accepted.

3. After cutting, bevel the end of the pipe using a beveling tool, portable type sander, or abrasive disc.

END OF SECTION

SECTION 35 23 21 - EXCAVATION AND BACKFILL FOR MARINE CONSTRUCTION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall perform all excavation, backfill, and disposal of all excess excavated material necessary to complete the Work as shown on the Drawings and as herein specified.

1.2 SUBMITTALS

A. The CONTRACTOR shall submit to the ENGINEER, for approval in advance, the source of the material to be supplied. The quarry or source will be evaluated by the ENGINEER prior to the delivery of any materials to the work site.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. Materials shall meet the requirements of the latest edition of the Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Constrution (SSRBC) unless otherwise specified in the Contract Documents. Equivalent materials may be sourced with the approval from the ENGINEER.

B. Excavated Material: Excavated material, except rock, shall be used in making backfill until a cover over the pipe is up to a 2-foot level below the original lake bottom. A cap of the excess excavated material shall be placed over the top of the cover stone shown on the Drawings.

C. Stone: The stone shall be dense, hard, sound, durable rock, angular, close-grained, and highly resistant to weathering and disintegration, and free of cracks, seams, overburden material and chert. The right shall be reserved to reject at the source or jobsite unsuitable material as determined by the ENGINEER at any time, and the material shall be removed from the work site at the CONTRACTOR’s expense.

D. Leveling Course and Backfill: IDOT CA-11 per Section 1004 of the SSRBC.

E. Cover, ballast, and riprap stone shall meet the requirements of IDOT Riprap #3, W50 x 100 riprap, meeting the following size gradation:

% Passing	By Weight
100	70 lbs. to 100 lbs.
50	10 lbs.
*	6 lbs
*	3 lbs.
8	1 lbs.

F. Periphery Armor Stone shall be 3 to 5 ton stone, well graded, dense, hard, durable rock, 70% shall be 4 tons or more. The minimum dimension of any piece shall not be less than one-half the maximum dimension.

PART 3 -- EXECUTION

3.1 EXCAVATION

A. The CONTRACTOR shall be responsible for excavation of underground and underwater utilities and structures prior to excavation and shall take precautions to avoid damaging utilities or structures in the process of the Work. Existing utilities and other structures, aboveground, underground or underwater that are disturbed or damaged shall be reported to the ENGINEER, and restoration and repairs shall be made immediately by the CONTRACTOR at its expense.

B. A trench shall be excavated in the lake bottom of sufficient depth to accommodate the work shown on the Contract Documents. The excavated material will be temporarily deposited at the sides of the trench and later used for backfilling the trench and placing a cap over the cover stone.

C. The trench shall be of sufficient depth throughout to provide a minimum depth of cover from the top of the pipe to the lake bottom of 4 feet or such greater depth as required by the Contract Drawings. At the depth shown on the Contract Drawings, the profile of the trench bottom shall be such that at no point will it be necessary to make more than a ¾-inch marine joint opening in laying the pipe.

D. In excavating for and installing the pipe, care shall be taken to keep the disturbance in the lake to a minimum. The method must be of a type to control or reduce dispersion of the excavated material. The CONTRACTOR shall use a clamshell with a cover or any other techniques and equipment that meet regulatory agency requirements as required by law for the protection of the environment. The method shall have been utilized by the CONTRACTOR for similar type of operation with proven successful record. In shallow, near-shore areas with depth of water less than 5 feet, a silt curtain together with other techniques and equipment mentioned above, whichever is most effective in containing any fines which cause siltation or which may drift offsite, shall be used. The CONTRACTOR shall provide information pertaining to the methods, equipment and techniques which it proposes to use in the excavation and backfilling of the trench to the ENGINEER for approval prior to the start of construction. Any work causing excessive disturbance shall be stopped until corrective measures are taken.

E. When excavating in the vicinity of any existing intake pipe inlet structures, the CONTRACTOR shall use suitable silt control techniques such as a closed covered clamshell, silt screens or other approved devices to prevent the carry-over of fine materials into the OWNER’s raw water supply system.

F. An excavation of suitable size and depth shall be made at the work site of the new intake cone structure so that the top of the structure when placed is nominally four (4) feet above the existing lake bottom. Excavated material must be removed from the work site to prevent it from being drawn into the new intake facilities or changing the contour of the lake bottom surrounding the intake cones.

3.2 BACKFILL

A. Intermittent Backfill

1. At alternate pipe sections along the pipeline, IDOT CA-11 gradation stone shall be placed to restrain and hold the pipe until backfilled as shown on the Contract Drawings.

2. The stone shall be placed by a clamshell bucket in a manner so as to minimize segregation and provide a well graded mass.

3. The stone shall not be dropped from a height exceeding 3 feet above the top of the pipe.

4. The stone shall be placed evenly on both sides of the pipe in layers not to exceed 12-inches in height from one side of the pipe to the other. The stone shall be placed up to a minimum of 1 foot over the top of the pipe.

5. Intermittent backfilling shall be installed as the pipe laying progresses. There shall never be more than 80 feet of pipe laid without intermittent backfilling completed as described above and as shown on the Drawings.

6. The backfilling shall not cover any marine joint of the laid pipe without the approval of the ENGINEER.

B. Trench Backfilling

1. The backfilling shall follow as closely as practicable behind the laying of the pipe.

2. Backfilling shall be done with extreme care to prevent large amounts of clay or trench spoil material causing a buildup of more than 12-inches of material on one side of the pipe greater than on the other side. Backfill material shall be placed on the sides of the pipe to fill in the sides, haunches, and underneath prior to placing material on top of the pipe.

3. Backfilling shall be done so that the backfill material is not dropped from over 3 feet above the pipe and shall be deposited in the trench in layers not exceeding 12-inches in thickness and carried across the width of the trench.

C. Cover Stone

1. On top of the trench backfill and within the walls of the excavated trench, a layer of riprap cover stone shall be placed over the backfilled pipeline.

2. The stone shall be placed by means of a chute, bucket, or other means which will deliver it from the scow to the lake bottom without dropping over 3 feet through the water.

3. The cover stone shall be placed in a continuous layer across and along the trench to a minimum depth of 2 feet in a uniform manner throughout the entire pipeline length.

4. Excess excavated material sidecast during excavation and not placed back into the trench, shall be placed on top of the cover stone for the entire length of the pipeline.

5. The protective rock around the intake cones shall be placed as shown on the Drawings and so as not to cause damage.

3.3 DISPOSAL OF EXCESS MATERIAL

A. The CONTRACTOR shall dispose of all excess excavated material and shall make all necessary arrangements for the excavated material, shall pay for all costs incidental to

securing permission for their use, and shall dispose of all excavated material without cost to the OWNER.

B. Disposition of excess material shall comply with all federal, state, and local laws and regulations.

END OF SECTION

SECTION 35 27 33 – MARINE WORKS

PART 1 -- GENERAL

1.1 SUMMARY

A. This section includes requirements for construction operations related to transporting components from land to water, and installing the components as to construct a new raw water intake at the Evanston Water Treatment Plant. Operations covered include, but are not necessarily restricted to, furnishing all components, materials, personnel, tools, and equipment (land based, floating, and submersible) necessary to transport materials, prepare the site, place components and materials, and perform tests and operations necessary to complete marine works operations in Lake Michigan

B. Major construction activities included in this Section consists of the following:

1. Marine excavation and dredging.

2. Furnish and install intake piping components and intake cones.

3. Shoreside modifications required to breach the shoreline at water treatment plant as necessary for connection to a new intake pipe along with any shoreside modifications per the Contract Documents.

4. Furnish and installing backfill and cover materials.

5. Handling of excavated materials as required by regulatory authroities and the Contract Documents.

6. Control of water quality during marine constrction activities.

C. CONTRACTOR shall be responsible for meeting the requirements of the U.S. Army Corps of Engineers, United States Coast Guard, and shipping industries affected by the construction in Lake Michigan for his work.

1.2 RELATED SECTIONS

A. 01 14 00 – Construction Constraints

B. 01 35 29 – Health, Safety, and Emergency Response Procedures.

1.3 DEFINITIONS

A. Marine Works Area: Within 50 feet of the alignment of the intake pipe or as indicated on the Contract Drawings.

1.4 SUBMITTALS

A. Marine Operations Plan

1. At least 60 days prior to the commencement of the Works, the CONTRACTOR shall provide the ENGINEER with a detailed Marine Operations Plan.

2. The CONTRACTOR’s detailed plan shall include, but not be limited to, the following:

    a. Specifications for all marine vessels proposed for the Works including vessels to be used for any geotechnical investigations. The specifications shall include limiting environmental conditions for continued operation.

    b. Operations procedures for the on-shore staging area, with particular regard to the requirements of the U.S. Coast Guard and other government departments or agencies having jurisdiction.

    c. The procedures to be followed to allow moorings to be decommissioned.

    d. Anchor placement locations and anchor laying procedures.

    e. Interfacing with the ship traffic on Lake Michigan and the procedures to be followed to minimize impact on the lake traffic.

    f. Guard vessels and site security.

    g. Operations of construction vessels.

    h. Transfer of personnel from vessels.

    i. Safety procedures relating to marine operations. Submit per the requirements of Section 01 35 29 – Health, Safety, and Emergency Response Procedures.

    j. Storm preparedness, particularly vessel capability to resist storm conditions, procedures to secure the works in the event of a storm and procedures to re-establish work following a storm.

    k. Emergency response procedures.

    l. Water quality monitoring.

    m. Oil spill prevention and containment procedures.

    n. Weather monitoring and weather warning procedures to be adopted.

    o. Description of crews and planned working hours.

    p. Space for the ENGINEER on marine vessels. This shall be to the same standard as for the CONTRACTOR’s senior supervisory staff. The ENGINEER shall be provided with all facilities to the level provided to the CONTRACTOR’s supervisory staff. CONTRACTOR shall provide transportation via crew boat from land and Evanston Water Treatment Plant to barge and marine operations at the ENGINEER and OWNER'S convenience.

    q. Contingency procedures in the event of:

        1) fire onboard construction and support vessels.

        2) man overboard.

3) medical evacuation.

4) loss of anchor or anchor chain on installation, materials and/or barge.

5) a vessel anchor becoming snagged on installed shaft liner, or other lake bed obstruction.

6) fog or low visibility conditions.

3. Detailed Installation Procedures

a. At least 60 days prior to the commencement of the Work, the CONTRACTOR shall submit to the ENGINEER detailed installation procedures. The procedures shall include but not be limited to:

1) Detailed summary of marine vessels, equipment, and personnel (including subcontractor personnel).

2) Surveying procedures for positioning of the vessels, positioning of construction equipment, dredging, placement of materials, and survey of completed intake.

3) Placement of pipe and appurtenances.

4) Contingency procedures.

5) Pipe joint make-up, installation procedures, and testing procedures.

6) Material procurement, stockpiling and placement procedures.

7) Water quality control measures.

8) Contingency measures to be implemented in the event that any of the above procedures prove to be ineffective.

b. The CONTRACTOR's installation procedures shall be documented in a step-by-step format with any necessary accompanying sketches of critical operations and shall include specifications of specialized equipment, construction tools, installation aids and materials. Supporting calculations shall be submitted for the Work if requested by the ENGINEER.

c. The CONTRACTOR shall supply to the ENGINEER copies of all shop or working Drawings which relate to fabrication of construction tools and installation aids required by the procedures.

d. No installation work shall be executed for any portion of the Work until the ENGINEER has approved the detailed procedures and the shop Drawings.

4. Equipment

a. At least 60 days prior to the commencement of the Works, the CONTRACTOR shall provide the ENGINEER with all technical details, applicable test

certifications and other relevant information on the following vessels and items of equipment:

1) Construction support vessels.

2) Monitoring equipment.

3) Cranage on the construction vessel and at the onshore staging area.

4) Dredging equipment.

5) Material placement and stockpiling.

6) Bulk storage and transportation of materials.

7) Mooring system including anchor size, type and windless capacity as well as holding power.

8) Marine survey and lakebed positioning system.

9) Underwater television system.

10) Remotely Operated Vehicle (ROV) and diving support system.

11) Life boats and life rafts.

12) Compressed air equipment.

13) Communications equipment.

14) Silt curtains and layout to be used.

15) Equipment to be used for any offshore geotechnical investigations if deemed necessary by the CONTRACTOR.

B. Daily Reports

1. The CONTRACTOR shall provide reports to the ENGINEER. The reports shall include:

a. Daily Marine Report, covering the 24 hours between 7:00am and 7:00am on consecutive days. The timing and content of the report is to be agreed with the ENGINEER and shall include, but not be limited to weather conditions experienced, weather forecast for next 48 hours, tasks undertaken, tasks completed, proposed tasks for next 24 hours, safety incidents, personnel movements, vessel movements.

b. Final Marine Installation Close-out Report: Within 30 days of completion of the Works the CONTRACTOR shall submit a final close-out report to the ENGINEER which shall include the following:

1) Actual installed coordinates of the intake and components.

2) An itemized list of components.

3) Any other items required by the ENGINEER.

1.5 QUALITY ASSURANCE

A. ENGINEER's inspection of the Work does not relieve the CONTRACTOR from the responsibility of applying effective quality assurance methods to all marine construction to assure that the Work is constructed in accordance with the Drawings and Specifications. It is the CONTRACTOR's responsibility to provide all means necessary to construct the Work within the tolerances and constraints called for in the Drawings and Specifications.

B. Inspection and the CONTRACTOR's Responsibility

1. The ENGINEER may inspect the Work during fabrication as well as during construction including, among others, surveying, excavation and backfilling, placement and completion of pipe, placement of intake cones, placement of stone and backfill, and other incidental marine activities.

2. The CONTRACTOR shall coordinate with the ENGINEER to assure that all concurrent inspection activities can be planned in advance, accounting for detailed construction operations as set forth in CONTRACTOR's Work Plan.

3. The CONTRACTOR shall provide the ENGINEER with equipment to monitor the CONTRACTOR's underwater video or other means of remote observation and measurement. The CONTRACTOR shall anticipate and allow for inspection delays that are typical for inspection that must be performed concurrent with construction operations.

1.6 PROJECT CONDITIONS

A. Borings have been made in the vicinity of the Work, at locations identified on the Drawings. The logs of the borings are provided in the Contract Documents. Interpretation of all data and reports for construction purposes is the responsibility of the CONTRACTOR.

1.7 PERMITS AND NOTICES

A. The CONTRACTOR shall be responsible for contacting all relevant authorities, issuing necessary notices, and for obtaining any additional permits necessary to perform the activities required for the Work. The relevant authorities include but are not limited to:

1. U.S. Coast Guard.

2. OSHA.

3. Great Lakes Shipping Association.

4. U.S. Army Corps of Engineers.

5. IDNR

6. IEPA

1.8 NAVIGATIONAL REQUIREMENTS

A. The CONTRACTOR shall comply with all applicable requirements of the U.S. Coast Guards, U.S. Army Corps of Engineers and other relevant regulatory agencies relating to the marine work activities, including:

1. Loading docks

2. Barge navigation

3. Towing

4. Anchoring

5. Marking and warning lighting of the Marine Works area

6. Signage of the Marine Works area and

7. Crew and material transport.

1.9 STAGING AREA

A. The CONTRACTOR shall be responsible for providing any staging areas it requires to complete the Work and shall obtain all necessary permits and satisfy all regulatory requirements related to such staging areas.

PART 2 -- NOT USED

PART 3 -- EXECUTION

3.1 GENERAL

A. The selection of onshore, floating and submersible equipment and the methods devised to construct the marine works within the tolerances specified are the option and responsibility of the CONTRACTOR. The CONTRACTOR shall verify all physical and environmental conditions at the site which may affect the Work. The CONTRACTOR shall allow for storms or adverse weather as part of the evaluation of equipment, methods and scheduling.

B. The CONTRACTOR shall provide an electronic positioning system for horizontal and vertical control capable of functioning during all hours of marine work. The CONTRACTOR shall use existing surveying monuments and control points and shall establish and maintain additional shore stations and control points as required to operate the offshore positioning system. The positioning system shall have the required accuracy to enable the lake shaft to be installed within the tolerances described in this section.

C. The sequencing of the Work is the CONTRACTOR’s option, with the exception of the first stage grouting operation. This should be undertaken within 24 hours after the installation of the shaft liner to reduce the risk of hole collapse and obstruction to the future grouting operations.

3.2 SURVEY FOR MARINE WORKS

A. The CONTRACTOR shall complete a hydrographic survey using a multi-beam echosounder (MBE) over the project work area described in the contract documents to identify possible obstructions on the lakebed.

B. The CONTRACTOR shall complete a lakebed survey over the entire Marine Works Area as needed to identify any cables or other significant metallic objects on or buried in the lakebed.

3.3 SITE ESTABLISHMENT

A. General: For the purpose of this Section, site establishment shall mean the tasks necessary to accurately deploy equipment on the lake bed at the specified locations prior to commencing underwater operations. The site shall be established in a manner which enables the subsequent phases of the Work to proceed properly and in accordance with the Contract.

B. Survey Method: The CONTRACTOR shall provide details of the proposed method and accuracy of survey to be adopted for the Works. The survey control marks for all marine works shall be on a common reference system as shown on Drawings.

C. Collection of Removed Material: All soil and rock material removed from the lake bed shall be collected in a suitable barge or other vessel. The collected material shall be disposed of at an approved disposal site in accordance with applicable regulatory requirements.

3.4 UNDERWATER INSPECTIONS

A. During the course of the marine work the CONTRACTOR shall be required to carry out both specified and miscellaneous underwater inspection surveys as part of the Work. The inspection surveys shall be performed by either remotely operated vehicles (ROV), remotely operated pan and tilt cameras, atmospheric diving systems (ADS) or divers. It shall be the CONTRACTOR’s responsibility to select and provide the equipment and personnel necessary to execute the underwater inspection surveys.

B. All underwater inspection surveys shall be carried out in accordance with procedures developed by the CONTRACTOR. The CONTRACTOR shall submit detailed underwater inspection procedures at the time of submitting the final installation procedures to the ENGINEER for approval.

C. The CONTRACTOR shall maintain digital video records and documentary logs of each lake bed inspection survey and these shall be made available to the ENGINEER upon request at any time throughout the Contract. Upon completion of the Work the inspection survey records and logs shall become the property of the OWNER.

D. The specified inspection surveys shall include, but shall not be limited to:

1. Lakebed Inspection Survey. The CONTRACTOR shall, as part of the Work, carry out an inspection survey of the proposed work area to ensure that the proposed site conforms to the requirements of the Specification and Drawings.

2. Pipe Inspection, including placement, backfill, joints, and elevation points.

3. Final Inspection Survey of site.

4. Where miscellaneous underwater inspection surveys from the installation vessel are requested by the ENGINEER during the course of the offshore works, the CONTRACTOR shall conduct such inspection surveys as part of the Works, providing the offshore works are not delayed by such inspection surveys.

E. Identified Tasks: The underwater support services shall be capable of performing at least the following tasks.

1. Visual lakebed inspection survey.

2. Monitoring of the installation of pipe and appurtenances.

3. Underwater photography and videos.

3.5 DREDGING ACTIVITIES

A. The CONTRACTOR shall be responsible for the removal of all obstructions to dredging in the vicinity of the work area and shall comply with all regulations and obtain all licenses needed to undertake such removal.

B. The CONTRACTOR shall ensure that the excavations are dredged to dimensions equal to or greater than those shown on the Drawings. The CONTRACTOR shall establish minimum temporary side slopes to suit his work methods and safety requirements based on his interpretation of the results of the geotechnical investigations.

C. The CONTRACTOR shall be responsible for disposal of all dredged materials in accordance with all applicable regulations. The CONTRACTOR shall submit complete details of his proposed dredging and disposal operations to the ENGINEER for review and approval.

3.6 WATER QUALITY MONITORING

A. The CONTRACTOR shall be responsible for all requirements for water quality monitoring as required by the contract documents and permitting requirements.

B. The CONTRACTOR shall be responsible for implementing and maintaining silt curtains, performing monitoring, or other measures to control turbity.

END OF SECTION

SECTION 40 05 00 - PIPING, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide piping systems indicated, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to piping in Divisions 33 and 40, and on the Drawings and as indicated in the Piping Schedule.

C. The Drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type. The Drawings are not pipe construction or fabrication drawings. The CONTRACTOR shall prepare pipe spooling and fabrication drawings and shall submit them to the ENGINEER for review.

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

1.2 DEFINITIONS

A. Pipe, piping, pipe work, pipe system, piping system, or similar words, singular or plural shall mean and include, any type of pipes, tubes, fittings, valves, piping specialties, appurtenances, supports, restraints, anchors, coatings and linings and items related to piping.

B. Submerged piping, underwater piping or similar words, shall include any piping located two feet above water surface in basins or tanks

C. Potable water or similar words, shall mean and include any type of potable water or process water that be deemed potable after treatment processes.

D. Corrosive service shall mean and include in locations listed below:

a. Buried locations

b. Submerged locations or submerged piping.

c. Inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump.

d. Chemical handling areas

e. Inside trenches, containment walls, and curbed areas

f. Locations indicated or designated in the contract documents.

1.3 CONTRACTOR SUBMITTALS

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

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

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

2. Welding Qualifications and Procedures

3. Pipe Supports: Submit pipe support fabrication drawings including calculations in accordance with Section 40 05 07 - Pipe Supports.

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

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

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

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

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

9. Expansion Joints: Submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature, and pressure ratings

10. Flexible Connectors: Submit pressure and thermal expansion calculations

C. Samples

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

D. Certifications

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

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

1.4 MATERIAL DELIVERY, STORAGE, AND PROTECTION

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

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

PART 2 -- PRODUCTS

2.1 GENERAL

A. Extent of Work

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

2. Materials in contact with potable water or process water that be deemed potable after treatment processes shall be listed as compliant with NSF Standard 61.

B. Piping Supports

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

2. Piping support seismic and wind loads shall be sized in accordance with the design criteria as shown on Drawings No. S-1, Structural – General Structural Notes– Design Criteria– Seismic Loads

C. Lining

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

D. Coating

1. Application, thickness, and curing of coating on buried pipe shall be in accordance with the applicable Sections of Division 33 and Section 09 96 00 - Protective Coating, unless otherwise indicated.

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

E. Pressure Rating

1. Piping systems shall be designed for the pressure as defined in respective pipe sections, or as indicated on the Piping Schedule, whichever is greater.

F. Inspection

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

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

G. Tests

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

2. Welds shall be tested as indicated.

3. The CONTRACTOR shall be responsible for performing material tests.

H. Welding Requirements

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

I. Welder Qualifications

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

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

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

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

2.2 PIPE FLANGES

A. General

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

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

3. Flanges for miscellaneous small diameter pipes shall be in accordance with the standards indicated for those pipes.

B. Pressure Ratings

1. 150 psig or less: Flanges shall conform to either AWWA C207 - Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ASME B16.5 - Pipe Flanges and Flanged Fittings, Class 150.

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

3. Selection Based on Test Pressure

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

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

C. Blind Flanges

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

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

D. Flange Coating

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

E. Flange Fasteners

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

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

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

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

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

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

f. All bolts fastening non-metallic flanges shall be provided with plain washers installed under both the bolt head and nut.

g. Washer materials shall be of the same material as the bolt.

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

i. Anti-galling compound used for stainless steel fasteners in LOX, nitrogen injection, oxygen, ozone process/off-gas/vent and ozone contactor maintenance air service shall be DuPont “Krytox”; or equal.

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

2. Fastener Material Group Numbering System

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

1) Material Group C1 (Carbon steel): ASTM A307 Grade B bolts, ASTM A563 Grade B nuts with ASTM F436 washers

2) Material Group C2 (Carbon steel): ASTM A193 Grade B7 bolts, ASTM A194 Grade 2H nuts with ASTM F436 washers

3) Material Group S1 (316 SS): ASTM A193, Grade B8M bolts, ASTM A194 Grade 8M nuts with Type 316 SS plain washers.

4) Material Group S2 (304 SS): ASTM A193, Grade B8 bolts, ASTM A194 Grade 8F nuts with Type 304 SS plain washers.

5) Material Group S3 (Hastelloy C-276): ASTM F468 N10276 bolts ASTM F467 N10276 nuts with type Hastelloy plain washers.

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

a. AWWA C115 ductile iron flanges - Material Group C1

b. AWWA C207 steel flanges - Material Group C2

c. ASME B31 group piping flanges – Material Group C2

d. Non-metallic pipe flanges - Material Group S1

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

f. Where mating flanges are of different flange material standards and the specified Fastener Material Groups are in conflict, then fasteners of the higher grade shall be utilized unless otherwise indicated. For the purpose of this requirement, the Material Groups in order of decreasing grade shall be S1, C2, C1. Provide insulating flange sets for dissimilar metal flanged piping to electrically isolate the dissimilar piping.

g. Where gaskets of Teflon or Viton-A are required, fasteners of Material Group C2 shall be utilized for all C1 flange standards.

4. Fastener Material Group Numbers used in Corrosive Service Applications

a. All Flange fasteners shall be of Material Group S1 unless S2 and S3 are otherwise indicated on the drawings.

F. Insulating Flanges

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

G. Insulating Flange Sets

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

2. For bolt diameters 1-1/2 inches or smaller, insulating sleeves and washers shall be one piece and shall be made of acetyl resin.

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

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

5. Insulating gaskets shall be full-face.

H. Insulating Flange Manufacturer, or Equal

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

2. **Fluid Sealing Products, Inc.**

3. **Enpro Industries, Inc. (GPT)**

I. Flange Gaskets

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

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

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

4. Unless otherwise indicated, flange gaskets up to 150 psi shall be EPDM sheet material, NSF 61 approved, **Garlock, Style 98206-U (unbranded), or similar products from John Crane, or equal**.

5. Unless otherwise indicated, flange gaskets up to 500 psi shall be aramid fiber with rubber binder material, NSF 61 approved, **Garlock, Style 3760-U (unbranded), or similar products from John Crane, or equal**.

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

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

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

2.3 PIPE THREADS

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

B. Unless otherwise indicated, use metal FNPT and plastic MNPT for threaded pipe connections between metal and plastic pipes.

2.4 THREADED INSULATING CONNECTIONS

A. General

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

B. Materials

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

2.5 MODULAR MECHANICAL SEALS FOR PIPING PENETRATIONS

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

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

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

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

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

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

G. Modular Mechanical Seals Manufacturer, or Equal

1. **EnPro Industries Company (GPT), Link-Seal**

2. **Proco Products, Inc., Pen-Seal**

3. **Spirax Sarco, Inc.**

PART 3 -- EXECUTION

3.1 GENERAL

A. This section specifies the general installation requirements for piping, valves, and related items and shall be installed in accordance with the manufacturer's technical data and printed instructions. Specific piping materials, systems, appurtenances, and related installation and testing requirements are specified in related sections of Divisions 01, 33, and 40, and as noted on the Drawings, Pipe and Valve Schedules.

B. Piping shall be installed in a neat and workmanlike manner, properly aligned and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipe shall afford maximum headroom and access to equipment, and where necessary piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points.

C. CONTRACTOR shall obtain the assistance of the pipe manufacturer to instruct the pipe fitters in the correct installation and support of the piping system. Valves and flanges attached to the pipe shall be provided with adequate supports.

D. Lined Piping Systems

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

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

3.2 INSTALLATION

A. Installation shall be free from defects. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true straight. Ends of threaded pipes shall be reamed and filed smooth. Groove ends shall be clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove. Fittings shall be equally cleaned before assembly.

B. Building gravity flow plumbing pipes shall be installed in a neat and workmanlike manner, in accordance with the prevailing plumbing and building codes. Pipes shall have the required slopes for proper drainage. Pipe locations inside buildings shall be coordinated with the rest of the WORK to avoid interferences and to provide sufficient headroom. Installations shall be acceptable to the local plumbing inspector.

C. Supports and Anchors: Piping supports, thrust, and seismic restraints shall be provided where shown on the Drawing or where determined to be required in according to Section 40 05 07 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipe shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences. Pipe shall be firmly supported with fabricated or commercial hangers or supports.

D. Piping Joints: Pipe joints requirements shall conform to the applicable piping sections of Division 33 and Division 40.

1. Threaded Joints: Pipe threads shall be full and cleanly cut with sharp dies. Not more than 3 threads shall remain exposed after installation.

2. Welded Joints: Welded joints shall conform to the specifications and recommendations of ASME B 31.1 - Power Piping. Welding shall be done by skilled and qualified welders. Pipe surface residues, oxides, and heat stains are to be removed from a field weld and the affected areas adjacent by the use of stainless steel wire brushes. For alloy and stainless steel pipe, the post welding surfaces shall be cleaned with a pickle agent such as nitric/hydrofluoric acid solutions or pickle paste or equal, then complete removal of the agent by wash the surface thoroughly with clean water.

3. Flange Joints: Flanged joints shall be made with gaskets with bolts and nuts as specified. Care shall be taken not to over-torque the bolts, in accordance with the manufacturer's written recommendations.

4. Fusion-Welded Joints: Fusion-welded joints shall be made with the manufacturer's recommended equipment on clean, dry pipe ends. The joints shall be made up at the recommended ambient temperatures, to the pipe manufacturer's written recommendations. The pipe supplier shall be consulted to obtain machinery and expertise for the joining by fusion welded of pipe and fittings. No pipe or fittings shall be joined by fusion by any of the Contractor's personnel unless they are adequately trained and qualified in the techniques involved. Butt fusion joining shall yield a joint strength equal to or greater than the tensile strength of the pipe. Socket fusion, extrusion welding and hot gas welding shall not be used for field connections.

5. Brazed and Soldered Joints: Brazed and soldered joints shall conform to the manufacturer’s recommendations and to the specifications and recommendations of ASME B 31.1 - Power Piping. Brazing shall be done by skilled and qualified welders. Prior to the application of flux, the ends of tubes shall be thoroughly dried and cleaned

6. Grooved Joints: Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the manufacturer's recommendations and conform to AWWA C 606 – Joints, Grooved and Shouldered Type. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.

7. Push On Joints: Push on joints and gasket installation shall be in accordance with the manufacturer's recommendations and lubricants. Pipe ends shall be beveled to facilitate assembly. Lubricants shall be suitable for potable water service and shall be kept clean in closed containers.

8. Solvent-Welded Joints: Solvent-welded joints shall be made with fresh primer and solvent cement on clean, dry pipe ends. The primer and cement cans shall be kept closed at all times and the joints shall be made up at the recommended ambient temperatures, to the pipe or cement manufacturer's written recommendations. PVC socket connections shall be joined with PVC cement conforming to ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC). CPVC socket connections shall be joined with CPVC solvent cement conforming to ASTM F493. For chemical service applications, solvent cement shall be formulated and labeled for use on that chemical.

9. Adhesive Joints: Adhesive joints shall be made with freshly-mixed 2-part epoxy on clean, dry pipe ends per pipe manufacturer recommendations. The joints shall be made up at the recommended ambient temperatures, to the pipe or adhesive

manufacturer's written recommendations. Pipe ends shall be inserted to the full depth of the socket.

E. Valves and Unions: Unless otherwise indicated, connections to fixtures, groups of fixtures and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

F. Branch Connections: Branch connections in horizontal runs of air and gas piping shall be made from the top of the pipe, to avoid drainage of condensate into the equipment. Unless otherwise indicated for threaded pipe connections between metal and plastic pipes, use metal FNPT and plastic MNPT.

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

G. Isolation Joints / Dielectric Protection: Provide electrically isolate connections between dissimilar metal piping connections. Electrical checks shall be made to assure no contact is made between dissimilar metal piping elements.

1. Use dielectric couplings specially designed for the prevention of galvanic reaction between dissimilar metals.

2. For flanged connections, use stainless steel bolts with isolation bushings, washers, and full-face flange gaskets.

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

I. Coating: Exposed pipes shall be coated with a finish coat to the pipe manufacturer's standard protective coating, with the manufacturer's recommended prime coat and a finish coat in accordance with Section 09 96 00 - Protective Coating.

J. Low points in piping systems and driplegs in steam, gas, and air systems shall have drainage valves.

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

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

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

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

4. Flange Bolts

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

b. Bolts shall be tightened with a torque wrench in a staggered sequence to the recommended torque for the applicable piping material per AWWA or manufacturer's recommendation. Care shall be taken to avoid over-torquing the bolts especially on plastic flanged joints.

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

d. In order to prevent induced stress or misalignment, do not over-torque connections to adjoining pump or equipment. Flanges shall not be deformed nor cracked.

3.3 INSPECTION

A. After completion of the WORK, cuttings, joining and wrapping materials, and other scattered debris shall be removed from the Site. The entire piping system shall be in a clean and functional condition.

B. Inspection: Finished installations shall be carefully inspected for proper joints and supports, interferences, and damage to pipe, fittings, and coating. Temporary plugs and covers shall be removed from openings and floor drains. Defective WORK shall be repaired to the satisfaction of the field engineer or plumbing inspector.

3.4 FIELD TESTING FOR PRESSURE PIPING

A. Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule for a period of not less than two hours without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices as part of the WORK. For additional testing requirements, refer to Section 01 74 30 - Pressure Pipe Testing and Disinfection.

B. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

C. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

3.5 FIELD TESTING FOR GRAVITY PLUMBING PIPING

A. Prior to enclosure or burying, drains and vents shall be tested in the presence of the local plumbing inspector and the ENGINEER for a period of not less than one hour, or as requested by the plumbing inspector if the request is more stringent. The CONTRACTOR shall furnish test equipment, labor, material, and devices as part of the WORK. Defective WORK shall be repaired to the satisfaction of the plumbing inspector, and the piping shall be re-tested until no leaks are found.

B. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure

shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

C. Testing and defective WORK shall be repaired to the satisfaction of the plumbing inspector.

END OF SECTION

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SECTION 40 05 02 - PIPING IDENTIFICATION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide identification for the piping and valves, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASME A13.1 Scheme for the Identification of Piping Systems

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings: Provide a list of the suggested wording for each pipe label and valve tag, prior to fabrication.

C. Samples

1. Sample of each type of identification device.

PART 2 -- PRODUCTS

2.1 EXPOSED PIPING OR ABOVE GROUND PIPING IDENTIFICATION

A. Pipe markers, type as indicated below, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.

1. Marker Type

a. Adhesive: Vinyl or polyester sheet with UV- resistant ink, shaped similar to pipe curvature and coated with pressure sensitive adhesive.

2. Marker Area: Sized per pipe size according to ASME A13.1 and conforming to the color codes in the Identification Colors table below.

3. Lettering: Sized per pipe size according to ASME A13.1 and conforming to the color codes in the Identification Colors table below.

4. Arrows: At least one arrow at each marker area, showing direction of flow.

B. Pipe 1-inch diameter and smaller or pipe not suitable for the marker type(s) listed above shall be identified with aluminum or stainless steel pipe identification tags with stamped-in ¼” high identification lettering.

C. Manufacturer or Equal.

1. **Seton Identification Products**, Opti Code Pipe Markers (adhesive type)

2. **Grainger, Inc.** (adhesive, snap around)

3. **Marking Services, Inc.**(adhesive, snap around)

2.2 BURIED PIPELINE IDENTIFICATION

A. Underground Warning Tape

1. Material:

a. Polyethylene tape or polyolefin film. The material and ink shall be chemically inert and shall not degrade when exposed to acids, alkalis and other destructive substances commonly found in soil.

b. 6” wide tape with a minimum 4 mil thickness.

c. Message: “CAUTION, LINE BURIED BELOW” with the name of the fluid service in black lettering on a colored background.

1) Water: Blue

2) Sewer: Green

3) Gas and other services: Yellow

4) Other services: colors as approved by the OWNER.

2. Manufacturer, or Equal

a. **Reef Industries, Inc.**

b. **Seton Identification Products**

c. **T. Christy Enterprises, Inc.**

B. Tracer Wire

1. Material:

a. Solid copper conductor with 30 mil HMWPE.

b. 10 gauge or thicker wire.

2. Manufacturer, or Equal

a. **Kris-Tech Wire**

b. **Corrpro Companies, Inc.**

2.3 EXISTING IDENTIFICATION SYSTEMS

A. In installations where existing piping identification systems have been established, the CONTRACTOR shall follow the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the system indicated herein.

2.4 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

A. Valves and sections of pipe that are too short to be identified with markers and arrows shall be identified with metal or plastic tags.

B. Metal tags shall be stainless steel with embossed lettering. Plastic tags shall be solid black plastic laminate with white embossed letters. Tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to the valves or short pipes.

C. Wording on valve tags shall describe the exact function of each valve (e.g., "HWR-BALANCING," "CLS THROTTLING", "RAS-PUMP SHUT-OFF," etc.) and include the valve number as indicated in the Contract Drawings. Wording on small pipes shall describe the contents of the pipe.

2.5 Pipe Coating:

A. Unless otherwise indicated, pipe coating shall be in conformance with Section 09 96 00 - Protective Coating.

PART 3 -- EXECUTION

3.1 GENERAL

A. Markers and identification tags shall be installed in accordance with the manufacturer's printed instructions, and shall be neat and uniform in appearance. Tags and markers shall be readily visible from all normal working locations.

3.2 VALVE TAGS

A. Valve tags shall be permanently attached to the valve or structure by means of 2 stainless steel bolts or screws.

3.3 MARKER LOCATIONS

A. Each pipe shall be marked at:

1. Intervals of 20-feet in straight runs.

2. At least once in every room.

3. Within 2 feet of turns, elbows, and valves.

4. On the upstream side of tees, branches, and other distribution points.

5. On both sides of walls and floors through which the piping passes.

3.4 IDENTIFICATION COLORS

1. Conform to the following color codes.

Pipe Contents		**Marker Color**	**Letter Color**	**Pipe Color**
Symbol	**Service**			
CLS	CHLORINE SOLUTION	yellow	black	
DR	DRAIN	green	white	
PW	POTABLE WATER	dark blue	white	
SPD	SUMP PUMP DISCHARGE	green	white	
RW	RAW WATER (NON-POTABLE WATER)	green	white	
VT	VENT	blue	white	

END OF SECTION

SECTION 40 05 06 – PIPE COUPLINGS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide pipe couplings indicated, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 05 00 - Piping, General apply to the WORK of this Section

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

D. The couplings, adapters and joints shall be provided with restraining devices to restrict pipe axial movement. Where the restraining devices and/or details are not indicated on the Drawings, it is the CONTRACTOR'S responsibility to provide the devices/details necessary to restraint the piping system.

E. The Items specified in this section include the following:

1. Groove Couplings
2. Sleeve Couplings
3. Flanged Coupling Adapters
4. Dismantling Joints
5. Expansion Joints
6. Flexible Connectors
7. Transition Couplings.
8. Quick Disconnect Couplings
9. Tapping Sleeves
10. Miscellaneous Adapters

1.2 CONTRACTOR SUBMITTALS

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

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

1. Product submittals, and shall be specifically identified with the applicable style or series designation, pressure rating and restraint system if applicable.
2. Couplings schedule or layout indicating where the couplings will be installed.

3. Expansion Joints: Submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and guides, including information on materials, temperature, and pressure ratings

4. Flexible Connectors: Submit pressure and thermal expansion calculations

C. Certifications

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

1.3 MATERIAL DELIVERY, STORAGE, AND PROTECTION

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

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

PART 2 -- PRODUCTS

2.1 GENERAL

A. Extent of Work

1. Piping couplings, adapters, joints and accessories shall be provided in accordance with the requirements of the applicable Sections of Divisions 33 and 40 and as indicated.

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

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

B. Pressure Rating

1. Couplings, adapters and joints shall be designed for the pressure as defined in respective pipe sections, or as indicated on the Piping Schedule, whichever is greater.

C. Seals

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

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

D. Coating

1. Couplings shall be lined and coated at the factory, unless otherwise indicated.

2. Coating shall be in accordance with the Section 09 96 00 - Protective Coating, unless otherwise indicated.

E. Dissimiliar Materials

1. Where connections between pipelines or equipment of corrosion causing dissimilar metals are required, the junction of the two dissimilar metals shall be made through a dielectric insulating coupling, union or other approved dielectric insulating device.

2.2 GROOVED TYPE COUPLINGS

A. General

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

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

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

   b. Rolled pipe ends are not acceptable as a means of connection for metallic piping.

3. Equipment connections with mechanical-type couplings shall be provided with rigid grooved couplings or flexible type coupling with harness in sizes where rigid type couplings are not available, unless thrust restraint is provided by other means.

4. Couplings shall be electrically bonded.

5. For uniformity and compatibility of the piping components; grooving tools, grooved fittings, couplings, and valves shall be furnished by the same manufacturer as the coupling.

B. Grooved Type Couplings Manufacturer, or Equal

1. Grooved couplings for ductile iron piping shall be provided with flush seal gaskets.

   a. **Victaulic Company,** Style 31 (flexible or rigid)

2. Grooved couplings for steel piping

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

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

   c. **Gustin-Bacon** (banded or grooved)

3. Grooved couplings for stainless steel piping

   a. **Victaulic Company**, Style 489 (rigid)

b. **Victaulic Company**, Style 77S (flexible)

2.3 SLEEVE COUPLINGS

A. General

1. Provide sleeve couplings specifically designed suitable for the fluid service and pressure rating.

B. Construction

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

2. Couplings shall be constructed without pipe stop.

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

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

5. For standard sleeve couplings, the coupling shall be either 5 or 7 inches long for pipe diameters up to and including 30-inch and 10 inches long for pipe diameters greater than 30-inch. For long sleeve couplings, the coupling shall be 16 inches long for all pipe diameters.

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

C. Insulating Sleeve Couplings

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

D. Sleeve-Type Couplings Manufacturer, or Equal

1. **World Wide Metric, Inc.** (Dresser), Style 38

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

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

2.4 FLANGED COUPLING ADAPTERS

A. Provide flanged coupling adapters specifically designed suitable for the fluid service and pressure rating.

B. Construction

1. Coupling bodies shall be fabricated from steel, ASTM A 512 - Cold-Drawn Butt-Weld Carbon Steel Mechanical Tubing or A 513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing.

2. Provide flanges in conformance with AWWA C207.

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

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

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

C. Flanged Couplings Adapter Manufacturer, or Equal

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

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

3. **JCM**, Model 303

4. **Hymax**, Grip or HLD 2 Flange Adaptor

5. **EBAA Iron**, Seies 2100

2.5 DISMANTLING JOINTS

A. Provide dismantling joints products specifically designed suitable for the fluid service and pressure rating.

B. Construction

1. Coupling bodies shall be fabricated from steel, ASTM A 512 - Cold-Drawn Butt-Weld Carbon Steel Mechanical Tubing or A 513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing.

2. Provide flanges in conformance with AWWA C207.

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

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

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

C. Dismantling Joints Manufacturer, or Equal

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

2. **Dresser**, Model 131

3. **JCM**, Model 309

2.6 EXPANSION JOINTS

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

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

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

2.7 FLEXIBLE CONNECTORS

A. Low-Temperature

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

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

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

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

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

2.8 TRANSITION COUPLINGS

A. Provide transition-coupling products specifically designed suitable for the fluid service and manufactured for the piping applications.

B. The transition couplings shall have function and design similar to the flexible couplings, joint and flanged coupling adapters for connecting piping having different outside diameters.

C. Couplings shall have a minimum pressure rating equal to the test pressure of the pipeline.

D. Couplings shall be provided with gaskets of a composition suitable for exposure to the liquid or gas within the pipe.Couplings shall be restrained type where indicated.

E. Transition Couplings Adapter Manufacturer, or Equal

1. **Smith-Blair**, Model 62

2. **Dresser**, Style 39 or 62

3. **EBAA Iron**, Seies 3800

4. **Hymax**, Grip, HLD, or HLD 2 Coupling

2.9 QUICK DISCONNECT COUPLINGS

A. Quick disconnect couplings shall be of the cam lock type (cam and groove type) consisting of a male adapter conforming to Specification MIL A-A-59326A. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leak proof up to full system pressures.

B. Each adapter shall be furnished with a dust cap complete with an 18-in long security chain of corrosion resistant material.

C. Unless otherwise indicated, the quick disconnect couplings shall be flanged connection to piping and materials shall be Type 316 stainless steel.

D. Quick connect couplings shall be as manufactured by LMC-Couplings; Dover Corporation; Ever-tite; or equal.

2.10 TAPPING SLEEVES

A. Provide tapping sleeve products specifically designed suitable for the fluid service and manufactured for the piping applications

B. Unless otherwise indicated, the tapping sleeves shall be of full circumference band with flanged outlet connection sized to ANSI class 150. Material of construction for the body and fastener shall be stainless steel.

C. Gasket material: Nitrile (Buna-N) or EPDM.

D. Tapping sleeves shall be as manufactured by Smith-Blair; Romac Industries; Dresser or equal.

2.11 MISCELLANOUS ADAPTERS

A. A special pipe adapter may be required to provide proper connection between different type of pipes and/or fittings. The adapter may be indicated on the Drawing with the pipe type or equipment. However, it is the CONTRACTOR'S responsibility to ensure proper connection between various type of pipes and pipe appurtenances. Provide adapters as required whether specifically indicated or not.

B. Provide piping adapter products specifically designed suitable for the fluid service and manufactured for the piping applications.

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation, inspection and field testing of the pipes shall in accordance with the requirements of Section 40 05 00 - Piping, General.

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

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

3.2 INSTALLATION

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

B. The couplings or the piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment.

C. Restrained Joints on couplings, adapters and joints

1. Couplings, adapters and joints on pressure lines shall be harnessed unless thrust restraint is provided by other means.

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

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

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

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

END OF SECTION

SECTION 40 05 07 - PIPE SUPPORTS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide pipe supports, hangers, guides, and anchors, complete and in place, as indicated in accordance with the Contract Documents.

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

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

D. 1. The CONTRACTOR shall provide supporting devices for supporting and restraining piping as indicated on the Drawings. Where pipe support devices and/or restraining details are not indicated on the Drawings, it is the CONTRACTOR'S responsibility to develop the details necessary to support and restraint the piping for a complete and functional pipe support system.

E. Seismic and Wind Forces

1. Pipe support details indicated in the Contract Drawings are sized for gravity loads only, and not designed to resist seismic and wind forces.

2. The CONTRACTOR shall arrange for the services of a registered professional engineer experienced in pipe support design to design such pipe supports to resist seismic and wind forces.

3. Piping support seismic and wind loads shall be sized in accordance with Section 01 33 17 – Structural Design, Support and Anchorage.

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

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

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

b. Pipe support schedule or layout indicating where the supports will be installed.

c. Calculations for special supports and anchors, stamped and signed by a registered professional engineer in the state where the project is located.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Code Compliance

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

2. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping – Chapter II, Part 5 -Expansion, Flexibility, and Pipe Supporting Element and design the pipe supporting elements in accordance with the rules of MSS SP-58 -Pipe Hangers and Supports – Materials, Design and Manufacture, except as supplemented or modified in this Section.

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

B. Structural Members

1. Wherever possible, pipes shall be supported from structural members.

2. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided by the CONTRACTOR.

3. Supplementary members shall be in accordance with the requirements of the Building Code and the American Institute of Steel Construction, and shall be as acceptable to the ENGINEER.

C. Pipe Hangers

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

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

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

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

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

D. Hangers Subject to Lateral or Axial Movement.

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

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

E. Thermal Expansion

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

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

F. Heat Transmission

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

G. Riser Supports

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

H. Freestanding Piping

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

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

I. Materials of Construction

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

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

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

4. Corrosive service areas are:

a. Chlorine feed system area

J. Point Loads

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

2. In order to avoid point loads, the supports on PVC, FRP, or other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields for general service and Type 316 stainless steel shields for chemical or corrosive areas.

K. Concrete Anchors

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

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

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

L. Noise Reduction

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

2.2 SUPPORT SPACING

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

B. Where pipe spacing are indicated on the Drawings and are referenced to a Standard Detail, that requirement shall take preference over the general requirements of this section.

C. Pipe support spacing shall not exceed the maximum indicated spans. Piping with grooved joint couplings, flexible joints, and bend fittings shall be balanced supported by a minimum of two pipe supports per pipe length, one at near each joint/fitting.

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

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

F. Steel Pipe

1. Where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing below.

2. Support Spacing for standard wall or heavier welded steel, stainless steel or alloy steel pipe.

Nominal Pipe Diameter, Inches	Maximum Span, ft (Water Service)	Maximum Span, ft (Gas or Vacuum Service)
1/2	6	7
3/4 and 1	8	9
1-1/4 to 2	10	12
3	12	14
4	14	15
6	16	18
8 and 10	18	20
12 and 14	20	24
16 and 18	22	26

20 and greater	24	30

G. Ductile Iron Pipe

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

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

Nominal Pipe Diameter, inches	Support Configuration
All diameters	two supports per pipe length, with one of the two supports located at a joint

H. Copper Tube

1. Where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing below:

Nominal Tube Size, inches	Support Spacing, feet	
	Water Service	Vapor Service
¾ and smaller	5	5
1	6	8
1-1/2 to 2-1/2	8	10
3	10	14
4	12	16
5	13	18
6	14	20
8	16	23

I. Schedule 80 PVC and CPVC Pipe

Nominal Pipe Size, inches	100 °F and below	101 to 120 °F	121 to 140 °F
1	5	3.5	3
1-1/2	5.5	3.5	3.5
2	6	4	3.5
3	7	4.5	4
4	7.5	5	4.5
6	9	6	5
8	9.5	6.5	5.5
10 and larger	10	7	6

J. Other Pipe Materials

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

2.3 MANUFACTURED SUPPORTS

A. Stock Parts

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

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

B. Manufacturers, or Equal

1. **Basic PSA, Inc.**

2. **Bergen-Paterson Pipe Supports Group**

3. **Grinnell**

4. **Power Piping Company**

5. **TOLCO (Eaton B-Line)**

2.4 COATING

A. Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and shall receive protective coatings in accordance with the requirements of Section 09 96 00 – Protective Coating.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General

1. Pipe supports, hangers, brackets, anchors, guides, and inserts shall be installed in accordance with the manufacturer's printed instructions and per ANSI/MSS SP-58 Pipe Hangers and Supports- Materials, Design, Manufacture, Selection, Application and Installation.

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

B. Appearance

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

2. Hanger rods shall be vertical, without offsets.

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

3.2 FIELD FABRICATION

A. Quality Control

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

2. Hangers and supports shall be neat in appearance without sharp corners, burrs, or edges.

END OF SECTION

SECTION 40 05 24 - STEEL PIPE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 40 05 00 - Piping, General and 40 05 07 – Pipe Supports apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. Water, Air, Fuel Gas, Oil, Steam, and Waste Service: Unless otherwise indicated, galvanized and black steel pipe shall conform to ASTM A 53 Type E or S- Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless or ASTM A 106 - Seamless Carbon Steel Pipe for High Temperature Service, Grade B, and shall be Schedule 40 or 80, as indicated in the Piping Schedule. Galvanized steel pipe shall not be cement mortar lined unless so indicated.

2.2 PIPE JOINTS

A. Black steel pipe for general service shall have threaded ends with NPT threads, welded joints, or flanged joints. Threaded joints shall be made up with Teflon tape and welded joints may have butt-weld fittings, socket-weld fittings, or flanges. Where indicated, black steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

B. Black steel pipe for chlorine or sulfur dioxide pressure service shall be socket-welded except where required to match mating fittings of vacuum regulator-check units, gas filters, valves, diaphragm units, gauges, and switches.

C. Galvanized steel pipe shall have threaded ends with NPT threads made up with Teflon tape. Where indicated, galvanized steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

D. Where pressure conditions permit, black and galvanized steel pipe may have push-on joints for compression type fittings. For high pressure service these joints shall be harnessed.

2.3 FITTINGS

A. Common Use: The following fittings shall be provided for galvanized or black steel pipe, as indicated in the Piping Schedule:

1. Threaded malleable iron fittings conforming to ASME B 16.3 - Malleable-Iron Threaded Fittings, Classes 150 and 300.

2. Threaded cast iron fittings conforming to ASME B 16.4 - Cast Iron Threaded Fittings, Class 125 and 250.

3. Forged steel socket welded fittings conforming to ASME B 16.11 - Forged Fittings, Socket - Welding and Threaded.

4. Butt welding fittings conforming to ASME B 16.9 - Factory-Made Wrought Steel Butt Welding Fittings, Schedule 40 or 80, as indicated.

5. Threaded cast iron drainage fittings conforming to ASME 16.12 - Cast Iron Threaded Drainage Fittings.

6. Flanged steel fittings conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.

7. Grooved ductile iron fittings with grooving dimensions conforming to AWWA C606 - Joints, Grooved and Shouldered Type.

8. Compression-type steel fittings with armored Buna S gaskets for plain end pipe.

B. Special Applications

1. Fittings for chlorine and sulfur dioxide under pressure shall be Class 3000. forged steel socket welded fittings conforming to ASTM A 105, Grade 2 - Forgings, Carbon Steel, for Piping Components, and Class 3000. forged steel fittings conforming to ASME B 16.11, as indicated in the Piping Schedule.

2. Flanges for chlorine and sulfur dioxide pressure service shall conform to ASTM A 105, ASME B 16.5, Class 300, with 1/16-inch raised face, with 1/16-inch high temperature, compressed, self-centering ring type gaskets to ASME B 16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.

3. Unions shall be 4 bolt tongue and groove, ammonia type, suitable for chlorine and sulfur dioxide service, with female threads and lead gaskets.Unions shall be rated for 500 lb. CWP service pressure, reducing-type, straight-type or blind-type, as required for the installation. Blind unions shall be provided as cleanouts where indicated, and straight unions shall be provided adjacent to each threaded valve or piece of equipment. Unions shall be as manufactured by **Henry Valve Company, Vogt Valve Co.,** or equal. High tensile alloy steel corrosion-resistant bolts and nuts shall be used with each set of flanged unions.

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation, inspection and field testing of the pipes shall in accordance with the requirements of Section 40 05 00 - Piping, General.

END OF SECTION

SECTION 40 05 30 - PVC PRESSURE PIPE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide polyvinyl chloride (PVC) pressure pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 40 05 00 - Piping, General and Section 40 05 07 – Pipe Supports apply to the WORK of this Section.

C. This Section includes PVC pressure pipe with solvent-welded, flanged, or threaded joints.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. PVC pipe shall be made from new rigid unplasticized polyvinyl chloride and shall be normal impact Type 1, Grade 1, class 12454, Schedule 80, listed as compliant with NSF Standard 61, unless otherwise indicated, in accordance with ASTM D 1785 –Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

2.2 PIPE JOINTS

A. Pipe joints shall be solvent-welded type with solvent cement and primer as recommended by the pipe manufacturer for the fluid in the pipe.

B. Threaded joints that are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape. Pipe threads shall conform to ASTM F 1498 - Taper Pipe Threads 60 Degrees for Thermoplastic Pipe and Fittings, and shall be full and cleanly cut with sharp dies or molded.

C. Flanged joints shall be made with solvent-welded PVC flanges, drilled to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated.

2.3 FITTINGS

A. Solvent Welded and Threaded Fittings: Solvent-welded and threaded fittings shall be Schedule 80 PVC fittings in accordance with ASTM D 2467 - Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

B. Flanged Fittings: Flanged fittings shall be Schedule 80 fabricated PVC fittings with Class 150 flanges in accordance with ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150.

2.4 SOLVENT CEMENT

A. Solvent cement shall be in accordance with ASTM D 2564 and certified by the manufacturer for the service of the pipe.

B. Potable Water Applications: Solvent cement listed by NSF for potable water applications.

C. Manufacturer: IPS Corporation, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation, inspection and field testing of the pipes shall in accordance with the requirements of Section 40 05 00 - Piping, General.

END OF SECTION

SECTION 40 05 31 - CPVC PRESSURE PIPE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide chlorinated polyvinyl chloride (CPVC) pressure pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 40 05 00 - Piping, General, and Section 40 05 07 - Pipe Supports apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. CPVC pipe shall be in accordance with ASTM F 441 - Chlorinated Poly (Vinyl Chloride) (CPVC), Plastic Pipe, Schedules 40, and 80, from all new compounds, meeting the requirements of Class 23447 per ASTM D 1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (PVC) Compounds. CPVC pipe shall be Schedule 80 pipe unless otherwise indicated. CPVC material shall be listed as compliant with NSF Standard 61.

2.2 PIPE JOINTS

A. Pipe joints shall be solvent-welded with solvent cement in accordance with ASTM F 493 - Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings, and with primer compatible with the solvent cement.

B. Threaded joints which are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape.

C. Flanged joints shall be made with solvent-welded CPVC flanges, drilled to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated.

2.3 FITTINGS

A. Solvent-Welded Fittings: Solvent-welded fittings shall be Schedule 80 CPVC fittings in accordance with ASTM F 439 - Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80. For chemical service applications, solvent cement shall be formulated and labeled for use on that chemical.

B. Threaded Fittings: Threaded fittings shall be Schedule 80 CPVC fittings in accordance with ASTM F 437 - Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

C. Flanged Fittings: Flanged fittings shall be Schedule 80 fabricated CPVC fittings with Class 150 flanges to ASME B 16.5 – Pipe Flanges and Flanged Fittings, Class 150.

2.4 SOLVENT CEMENT

A. Solvent cement shall be in accordance with ASTM F 493.

B. Chemical service applications: Primer: IPS Type P-70 IPS, Cement: IPS Type 724 and certified by the manufacturer for the chemical services.

C. Manufacturer: IPS Corporation or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation, inspection and field testing of the pipes shall in accordance with the requirements of Section 40 05 00 - Piping, General.

END OF SECTION

SECTION 40 05 32 - HIGH DENSITY POLYETHYLENE (HDPE) PIPE

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide High Density Polyethylene (HDPE) pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 40 05 00 - Piping, General, and Section 40 05 07 - Pipe Supports apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. High Density Polyethylene (HDPE) Pipe shall be butt fusion welded and manufactured accordance with ASTM F 714 – Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter and AWWA – C901 Polyethylene (PE) Pressure Pipes and Tubing, ½ Through 3 in. for Water Service. HDPE pipe shall be DR 9 unless otherwise indicated. Pipe material shall be PE4710, and shall be listed as compliant with NSF Standard 61.

B. HDPE pipe shall conform to AWWA C901 Pressure Class 250. Pipe shall be delivered in coils of minimum 1000-foot lengths.

2.2 PIPE JOINTS

A. Plain end pipe and fittings shall be joined using butt fusion.

B. A hydraulic fusion machine shall be used to fusion weld pipe, and the butt fusion procedures shall be in accordance with the manufacturer recommendations. The fusion equipment operator shall receive training from the manufacturer using the recommended procedure. The Contractor shall be responsible to verify that the fusion equipment is in good operating condition and that the operator has been trained within the past twelve months. Fusion beads shall not be removed.

2.3 FITTINGS

A. Pipe fittings shall be manufactured according to ASTM D3261.

B. All fittings shall be suitable for use under pressure and conform to AWWA C901. Molded and fabricated fittings shall have a pressure rating equal to the pipe.

2.4 Manufacturers, or Approved Equal

A. **Isco Pipe**

B. **PolyPipe**

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation, inspection and field testing of the pipes shall in accordance with the requirements of Section 40 05 00 - Piping, General.

B. Manufacturer shall verify outside diameter, wall thickness, length, roundness and surface finish of manufactured pipe prior to leaving plant and shall submit certification at time of pipe delivery to the site.

3.2 INSTALLATION

A. Prior to final installation, pipe shall be straightened using equipment specifically designed for the purpose of removing coil memory. Equipment shall be McElroy LineTamer or approved equal.

B. Pipe located within the 60” PCCP pipe shall be bundled with the power cables every 20 ft using stainless steel and rubber straps. Following the bundling, the cable/feed line bundle shall be pulled through the 60” intake pipe. Bundle shall be weighed or anchored down. Method of weighing/ anchoring shall be shown on shop drawing submittal Owner approval.

C. Following installation, HDPE pipe shall be pressure tested using 50 psi water. Coordinate pressure test with Owner.

END OF SECTION

40 91 00 - PROCESS CONTROL AND INSTRUMENTATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents as part of the bid price. The requirements of this Section apply to every component of the PICS unless indicated otherwise.

B. SYSTEM INTEGRATOR shall integrate control devices supplied under this contract with existing PCIS.

C. The requirements of this Section apply to every component of the PCIS unless indicated otherwise.

D. Responsibilities

1. The CONTRACTOR, through the use of single System Supplier and qualified electrical and mechanical installers, shall be responsible to the OWNER for the implementation of the PCIS. The cost of these services shall be included in the bid price without additional compensation.

2. The SYSTEM INTEGRATOR shall be responsible to the Contractor for the integration of the PCIS with existing devices and devices provided under other sections with the objective of providing a completely integrated control system free of signal incompatibilities. The CONTRACTOR shall integrate SYSTEM INTEGRATOR's Scope and Allowance proposal into the SUB CONTRACTOR WORK performed under this contract.

3. The CONTRACTOR shall be responsible for coordination with System Supplier and System Integrator for loop testing from the field instruments and control panels to the existing PLC STA and SCADA. Pre-commissioning and commissioning as denoted in this section should involve Intake Heater System, communications to the existing PLC STA (Allen Bradley ControlLogix) and integration into the overall City SCADA system.

4. As a minimum, the Instrumentation Supplier shall perform the following WORK:

a. Implementation of the PCIS

1) prepare hardware submittals

2) design, develop, and electronically draft loop drawings and control panel designs

3) prepare the test plan, the training plan, and the spare parts submittals

4) procure hardware

5) fabricate panels

6) perform factory tests on panels

7) perform bench calibration and verify calibration after installation

8) oversee and certify installation

9) oversee, document, and certify loop testing

10) oversee, document, and certify system commissioning

11) prepare Technical Manuals

12) conduct training classes

13) prepare record drawings

5. Any Instrumentation Supplier responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the Instrumentation Supplier. Additional requirements in this Section and throughout Division 40 that are stated to be the CONTRACTOR's responsibility may be performed by the prequalified Instrumentation Supplier if the CONTRACTOR and Instrumentation Supplier so determine.

E. Certification of Intent

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

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

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

c. It shall include the following statements:

1) (Corporate name of Instrumentation Supplier) "hereby certifies intent to assume and execute full responsibility to the CONTRACTOR to perform all tasks defined under Section 409100 - Paragraph 1.1C3 in full compliance with the requirements of the Contract Documents."

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

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals and the following:

1. The CONTRACTOR shall coordinate the instrumentation WORK so that the complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and record drawings.

2. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized

informally by the ENGINEER, but will not alter the scope of WORK or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

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

B. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a Presubmittal Conference within 30 Days after award of the Contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the CONTRACTOR intends to carry out its responsibilities for Shop Drawing submittal on the WORK to be provided under this Section. The CONTRACTOR, the Instrumentation Supplier, and the ENGINEER shall attend. Both the CONTRACTOR and the ENGINEER may invite additional parties at their discretion.

2. The CONTRACTOR shall allot minimum 2 hours for the Conference.

3. The CONTRACTOR shall present the following for discussion at the Conference:

   a. A list of equipment and materials required for the PCIS and the manufacturer's name and model number for each proposed item.

   b. A list of proposed clarifications to the Contract Documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the ENGINEER.

   c. An exact one-to-one sample of each type of submittal herein.

   d. A flow chart showing the steps to be taken in preparing and coordinating each submittal to the ENGINEER.

   e. A bar-chart type schedule for system-related activities from the Presubmittal Conference through start-up and training. Dates of submittals, design, fabrication, programming, factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.

   f. An overview of the proposed training plan. The OWNER's staff and ENGINEER will review the overview and may request changes. Changes to the proposed training shall be resolved at the pre-submittal conference. The overview shall include the following for each proposed course.

      1) Course title and objectives.

2) Prerequisite training and experience of attendees.

3) Course content - a topical outline.

4) Course duration.

5) Course format - lecture, laboratory demonstration, etc.

4. The CONTRACTOR shall furnish 3 copies of the items above to the ENGINEER.

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

C. Shop Drawings

1. General

a. Preparation of Shop Drawings shall not commence until adjournment of the Presubmittal Conference.

b. Shop Drawings shall include the letter head or title block of the Instrumentation Supplier. The title block shall include, as a minimum, the Instrumentation Supplier's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing. The quantity of submittal sets shall be as indicated in Section 01 33 00 - Contractor Submittals.

c. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized and incomplete submittals for a given loop will not be accepted.

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

e. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders and other equipment related to the PCIS shall be included in the Shop Drawing submittal.

2. Hardware Equipment Submittal: The CONTRACTOR shall submit a complete bound package at one time within 30 Days after the commencement date stated in the Notice to Proceed, including:

a. A complete index which lists each device by tag number, type, and manufacturer. A separate technical brochure or bulletin shall be included with each instrument data sheet. The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure or bulletin may cover multiple identical uses of that instrument in that system. Each brochure or bulletin shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags.

b. Fully executed data sheets according to ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, for each component, together with a technical product brochure or bulletin. The technical product brochures shall be complete enough to verify conformance to Contract Document requirements. The data sheets, as a minimum, shall show:

   1) Component functional description used in the Contract Documents

   2) Manufacturer's model number or other product designation

   3) Project tag number used in the Contract Documents

   4) Project system or loop of which the component is a part

   5) Project location or assembly at which the component is to be installed

   6) Input and output characteristics

   7) Scale, range, units, and multiplier (if any)

   8) Requirements for electric supply (if any)

   9) Requirements for air supply (if any)

   10) Materials of component parts to be in contact with or otherwise exposed to process media and corrosive ambient air

   11) Special requirements or features

c. Flow meter sizing calculations. Calculations shall be submitted on the instrument manufacturer letterhead and shall include the following:

   1) Proposed meter size based on indicated minimum, maximum and average flow rates

   2) Guaranteed meter accuracy based on the upstream and downstream straight runs associated with the location of each meter

   3) Permanent head loss associated with each meter

   4) Flow vs. differential pressure curves for each head-type device. For compressible fluids, curves shall be pressure- and temperature-compensated.

   5) References to ASME standard equations used

   6) Values used for every parameter used in calculations

d. Priced list of spare parts for every device.

e. Instrument installation, mounting, and anchoring details shall be submitted in an electronic AutoCAD and hard copy format. Each instrument shall have a dedicated 8-1/2 inch by 11-inch detail that only pertains to the specific instrument

by tag number. Each detail shall be certified by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable. These certifications shall be embedded in the CAD files and also appear as a stamp on the hard copies. As a minimum, each detail shall have the following contents;

1) show necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor.

2) ambient temperature and humidity of the environment that the instrument is to be installed in.

3) corrosive qualities of the environment that the instrument is to be installed in.

4) hazardous rating of the environment that the instrument is to be installed in.

5) process line pipe or tank size, service, and material.

6) process tap elevation and location.

7) upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.

8) routing of tubing and identification of supports.

9) mounting brackets, stands, and anchoring devices.

10) conduit entry size, number, location, and delineation between power and signal.

11) NEMA ratings of enclosures and components.

12) clearances required for instrument servicing.

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

3. Project-Wide Loop Drawing Submittal: The CONTRACTOR shall furnish a Project-wide Loop Drawing Submittal (PLDS) which completely defines and documents the contents of each monitoring, alarming, interlock, and control loop associated with equipment provided under Division 40 sections, equipment provided under sections in other Divisions, existing, and OWNER-furnished equipment which is to be incorporated into the PCIS. The PLDS shall be a singular complete bound package electronically drafted in AutoCAD, submitted within 60 Days after Contract Award, and shall include the following:

   a. A complete index in the front of each bound volume. The loop drawings shall be indexed by systems or process areas. Loops shall be tagged in a manner

consistent with the Contract Documents. Loop drawings shall be submitted for every analog and discrete monitoring and control loop.

b. Drawings showing definitive diagrams for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component of each loop or system using legend and symbols from ISA S5.4 - Instrument Loop Drawings, extending the format as shown on Drawing GI-1 and as defined by the most recent revision in ISA. Panel drawings showing PLC I/O card wiring and field terminations are not acceptable as loop drawings. Each system or loop diagram shall be drawn on a separate drawing sheet with no more than 10 loops per drawing. Loop drawings shall be developed for loops in equipment vendor-supplied packages, equipment provided under Division 40, and OWNER-furnished equipment. In addition to the expanded ISA S5.4 requirements, the loop diagrams shall also show the following details:

1) Functional name of each loop

2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.

3) MCC panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.

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

5) Vendor panel, instrument panel, conduit, junction boxes, equipment and SCADA terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

c. Itemized instrument summary. The summary shall be prepared with Microsoft Access software and shall be submitted on CD and hard copy. The instrument summary shall list all of the key attributes of each instrument provided under this Contract. As a minimum, attributes shall include:

1) Tag number

2) Manufacturer

3) Model number

4) Service

5) Area location

6) Calibrated range

7) Loop drawing number

8) Associated LCP, PLC, PCM, or RTU

4. Startup Submittals

a. The CONTRACTOR shall submit the proposed procedures to be followed during startup of the PCIS and its components.

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

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

5. Training Submittals: Subsequent to the receipt of the OWNER's and ENGINEER's inputs made at the Presubmittal Conference, the CONTRACTOR shall submit a training plan which includes:

a. A resubmittal of the training plan overview from the Presubmittal Conference with incorporation of modifications agreed upon at that meeting.

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

c. Resumes of the instructors who will actually implement the plan.

D. Technical Manual

1. General: Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the WORK.

2. The Technical Manual shall have the following organization for each process:

a. Section A - Process and Instrumentation Diagrams

b. Section B - Loop Descriptions

c. Section C - Loop Drawings

d. Section D - Instrument Summary

e. Section E - Instrument Data Sheets

f. Section F - Sizing Calculations

g. Section G - Instrument Installation Details

h. Section H - Test Results

3. Signed results from Loop Testing, Precommissioning, and Performance Testing shall be included in Section H.

4. Initially, 2 sets of draft Technical Manuals shall be submitted for review after return of favorably reviewed Shop Drawings and data required herein. Following the

ENGINEER's review, one set will be returned to the CONTRACTOR with comments. The Manuals shall be revised and amended as required and the final Manuals shall be submitted 15 Days prior to startup of systems.

E. Record Drawings

1. The CONTRACTOR shall keep current a set of complete loop and schematic diagrams which shall include field and panel wiring, piping and tubing runs, routing, mounting details, point-to-point diagrams with cable, wire, tube and termination numbers. These drawings shall include every instrument and instrument element. One set of drawings electronically formatted in AutoCAD and 2 hard copies shall be submitted after completion of Precommissioning tasks but prior to Performance Testing. Such drawings shall be submitted for review prior to acceptance of the completed WORK by the OWNER.

1.3 MILESTONE CASH FLOW SCHEDULE

A. **General:** The CONTRACTOR shall develop a schedule and cash flow schedule based upon the payment milestones below for inclusion in the submittals of Section 01 32 16 – CPM Construction Schedule. Failure to submit the schedule and cash flow schedule shall be cause for withholding any progress payment due for instrumentation WORK under sections in this Division.

B. **Payment Milestones:** This schedule lists the percentage of the lump sum price of Instrumentation which will be payable to the CONTRACTOR upon task completions. Payment shall be in accordance with the General Conditions.

1.	Hardware Equipment Submittal approved	5 percent
2.	Project-wide Loop Drawing Submittal approved	10 percent
3.	Control Panel Engineering Submittals approved	5 percent
4.	Final Technical Manual submitted	5 percent
5.	Completion of precommissioning accepted	30 percent
6.	Thirty-day performance test successfully completed	25 percent
7.	Notice of acceptance issued	20 percent

1.4 SPECIAL CORRECTION OF DEFECTS REQUIREMENTS

A. **Extended Period for Correction of Defects:** The CONTRACTOR shall correct defects in the PCIS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 3 Days after notification.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Code and Regulatory Compliance:** PCIS WORK shall conform to or exceed the applicable requirements of the National Electrical Code. Conflicts between the requirements of the Contract Documents and any codes or referenced standards or specifications shall be resolved according to Section 01 42 19 - Reference Standards.

B. **Current Technology:** Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

C. **Adverse Environmental Impact**: No component of an instrumentation system shall contain liquid mercury.

D. **Hardware Commonality:** Instruments which utilize a common measurement principle (for example, d/p cells, pressure transmitters, level transmitters that monitor hydrostatic head) shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

E. **Loop Accuracy:** The accuracy of each instrumentation system or loop shall be determined as a probable maximum error; this shall be the square root of the sum of the squares of certified "accuracies" of the designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual instrument shall have a minimum accuracy of plus and minus 0.5 percent of full scale and a minimum repeatability of plus and minus 0.25 percent of full scale unless otherwise indicated. Instruments that do not conform to or improve upon these criteria are not acceptable.

F. **Instrument and Loop Power:** Power requirements and input/output connections for components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2 wire" transmitters is preferred, and use of "4 wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.

G. **Instrument Air:** Dry, filtered control air at 30 psig nominal pressure shall be piped to field instruments and instrument panels requiring air. Each field instrument shall be provided with an integral, non-adjustable filter/regulator assembly to provide regulated air. Each instrument panel requiring air shall be provided with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments. Air shall be filtered to 5-micron maximum particle size. Pressure reducers and regulators shall be furnished with additional instrumentation as required.

H. **Loop Isolators and Converters:** Signal isolators shall be provided as required to ensure adjacent component impedance match where feedback paths may be generated, or to maintain loop integrity during the removal of a loop component. Dropping precision wirewound resistors shall be installed at field side terminations in the control panels to ensure loop integrity. Signal conditioners and converters shall be provided where required to resolve any signal level incompatibilities or provide required functions.

I. **Environmental Suitability:** Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

J. **Signal Levels:** Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 milliamperes dc except as indicated. Signals within enclosures may be 1 to 5 volts dc. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.

K. **Control Panel Power Supplies:** Control panels shall be provided with redundant power supplies which are configured in a fault-tolerant manner to prevent interruption of service upon failure and interruption of service necessitated by the replacement of a power supply. Power supplies shall have an excess rated capacity of 40 percent. The failure of a power supply shall be annunciated at the control panel and repeated to the SCADA System.

L. **Alternative Equipment and Methods:** Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process of Section 01 60 00 - Products, Materials, Equipment, and Substitutions. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

2.2 OPERATING CONDITIONS

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

Environment	Interior of the water tank facility
Temperature Range	32 through 104 degrees F
Thermal Shock	1 degree F per minute, max
Relative Humidity	20 through 90 percent, non-condensing

2.3 SPARE PARTS AND SPECIAL TOOLS

A. The ENGINEER will select the required spare parts from the priced list of spare parts in the Hardware Equipment Submittal, and the CONTRACTOR shall furnish them. The CONTRACTOR will be paid from the corresponding allowance item in the Bid, and the total price will not exceed the amount of the allowance item.

B. The CONTRACTOR shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided. After approval the CONTRACTOR shall furnish tools on that list.

C. Special tools and spare parts shall be submitted before startup commences, suitably wrapped and identified.

2.4 FACTORY TESTING

A. The CONTRACTOR shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the ENGINEER and OWNER to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices. A minimum of 10 Days notification shall be furnished to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER's approval.

PART 3 -- EXECUTION

3.1 PRODUCT HANDLING

A. **Shipping Precautions**: After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. **Special Instructions:** Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. **Tagging:** Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. **Storage:** Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.2 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall furnish the following manufacturer's services for the instrumentation listed below:

1. Perform bench calibration

2. Oversee installation

3. Verify installation of installed instrument

4. Certify installation and reconfirm manufacturer's accuracy statement

5. Oversee loop testing, prepare loop validation sheets, and certify loop testing

6. Prepare pre-commissioning validation sheets, oversee pre-commissioning, and certify when pre-commissioning is completed.

7. Train the OWNER's personnel

3.3 INSTALLATION

A. General

1. Instrumentation, including instrumentation furnished under other Divisions, shall be installed under Division 40 and the manufacturers' instructions.

2. Equipment Locations: The monitoring and control system configurations indicated are diagrammatic. The locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.

B. Conduit, Cables, and Field Wiring

1. Conduit shall be provided under Division 26 without delay to the WORK of Division 40.

2. Process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments, PLC input and output wiring, and other field wiring and cables shall be provided under Division 26.

3. SCADA equipment cables, communication networks shall be provided under Division 40.

4. Terminations and wire identification at PCIS equipment furnished under this or any other Division shall be provided under Division 40.

C. **Instrumentation Tie-Downs:** Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

D. **Existing Instrumentation:** Each existing instrument to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.

E. **Ancillary Devices:** The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. The CONTRACTOR shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.

F. **Installation Criteria and Validation:** Field-mounted components and assemblies shall be installed and connected according to the requirements below:

1. Installation personnel have been instructed on installation requirements of the Contract Documents.

2. Technical assistance is available to installation personnel at least by telephone.

3. Installation personnel have at least one copy of the approved Shop Drawings and data.

4. Instrument process sensing lines shall be installed in conduit under Section 26 00 00 - Electrical General Provisions. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.

5. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.

6. Differential pressure elements shall have 3 valve manifolds.

7. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.

8. Power and signal wires shall be terminated with crimped type lugs.

9. Connectors shall be, as a minimum, water tight.

10. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.

11. Wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.

12. Mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.

13. Verify the correctness of each installation, including polarity of electric power and signal connections, and make sure process connections are free of leaks. The CONTRACTOR shall certify in writing that discrepancies have been corrected for each loop or system checked out.

14. The OWNER will not be responsible for any additional cost of rework attributable to actions of the CONTRACTOR or the Instrumentation Supplier.

3.4 CALIBRATION

A. **General:** Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. **Calibration Points:** Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. **Bench Calibration:** Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the ENGINEER.

D. **Field Calibration:** Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. **Analyzer Calibration:** Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. **Calibration Sheets:** Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name
2. Loop number
3. Tag number
4. Manufacturer
5. Model number
6. Serial number
7. Calibration range
8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span
9. Switch setting, contact action, and deadband for discrete elements
10. Space for comments
11. Space for sign-off by Instrumentation Supplier and date
12. Test equipment used and associated serial numbers

G. **Calibration Tags:** A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the Instrumentation Supplier sign the tag when calibration is complete. The ENGINEER will sign the tag when the calibration and testing has been accepted.

3.5 LOOP TESTING

A. **General:** Individual instrument loop diagrams per ISA Standard S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the ENGINEER for review prior to the loop tests. The CONTRACTOR shall notify the ENGINEER of scheduled tests a minimum of 15 Days prior to the estimated completion date of installation and wiring of the PCIS. After the ENGINEER's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop check shall be witnessed by the ENGINEER.

B. **Control Valve Tests:** Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.

C. **Interlocks:** Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.

D. **Instrument and Instrument Component Validation:** Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

E. **Loop Validation:** Controllers and electronic function modules shall be field tested and exercised to demonstrate correct operation. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by Contract requirements or by published manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated. Each analog network shall be tested by applying simulated analog or discrete inputs to the first element of an analog network. For networks which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data shall be recorded on test forms attached at the end of this Section which include calculated RMS summation system accuracy tolerance requirements for each output.

F. **Loop Validation Sheets:** The CONTRACTOR shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the Instrumentation Supplier:

1. Project name
2. Loop number
3. Tag number, description, manufacturer, and model number for each element
4. Installation bulletin number
5. Specification sheet number
6. Loop description number
7. Adjustment check
8. Space for comments
9. Space for loop sign-off by Instrumentation Supplier and date
10. Space for ENGINEER witness signature and date

G. **Loop Certifications:** When installation tests have been successfully completed for individual instruments and separate analog control networks, a certified copy of each test form signed by the ENGINEER or the ENGINEER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the instrumentation has been successfully calibrated, inspected, and tested.

3.6 PRE-COMMISSIONING

A. **General:** Pre-commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

B. **Pre-commissioning Procedures and Documentation:** Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system precommissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied.

C. **Operational Validation:** Where feasible, system pre-commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent

possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software-based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

D. **Loop Tuning:** Electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

E. **Pre-commissioning Validation Sheets:** Pre-commissioning shall be documented on one of 2 types of test forms as follows:

1. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:

    a. Project name

    b. Loop number

    c. Loop description

    d. Tag number, description, manufacturer, and data sheet number for each component.

    e. Space for sign-off and date by both the Instrumentation Supplier and ENGINEER.

2. For functions that cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description the following information shall be included:

    a. Specification page and paragraph of function demonstrated

    b. Description of function

    c. Space for sign-off and date by both the Instrumentation Supplier and ENGINEER

F. **Pre-commissioning Certification:** The CONTRACTOR shall submit an instrumentation and control system pre-commissioning completion report which shall state that Contract requirements have been met and shall include a listing of instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing.

Acceptance of the instrumentation and control system pre-commissioning testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

3.7 ON-SITE SUPERVISION

A. The CONTRACTOR shall furnish the services of an on-Site resident engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The resident engineer shall be present during the total period required to effect a complete operating system. A team of engineering personnel shall be at the Site for 8 hours to check equipment, perform the tests indicated in this Section, and furnish startup services.

3.8 COMMISSIONING

A. The entire WORK shall operate for 21 Days longer than the commissioning period in Section 01 75 00 without failure.

B. In addition to the commissioning requirements of Section 01 75 00, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements.

C. If any component fails during the performance test, it shall be repaired or replaced, and the performance test shall be restarted at time zero on another 21 Day period.

3.9 TRAINING

A. **General:** The CONTRACTOR shall train the OWNER'S personnel on the maintenance, calibration, and repair of instruments provided under this Contract.

B. **Instructions:** The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. **Duration:** Each training class shall be a minimum of 2 hours in duration and shall cover, as a minimum, operational theory, maintenance, troubleshooting/repair, and calibration of the instrument.

D. **Schedule:** Training shall be performed during the pre-commissioning phase of the project. The training sessions shall be scheduled a minimum of 1 week in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated.

E. **Agenda:** The training shall include operation and maintenance procedures, troubleshooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment.

F. **Documentation:** Within 10 Days after the completion of each session the CONTRACTOR shall submit the following:

1. A list of OWNER personnel who attended the session.

2. An evaluation of OWNER personnel via written testing or equivalent evaluation.

3. A copy of the training materials utilized during the lesson with notes, diagrams, and comments.

3.10 CRITERIA FOR SUBSTANTIAL COMPLETION

A. For the purpose of this Section and all Division 40, the following conditions shall be fulfilled before the WORK is considered substantially complete:

1. Submittals have been completed and approved.

2. The PCIS has been calibrated, loop tested, and pre-commissioned.

3. The OWNER training has been performed.

4. Spare parts and expendable supplies and test equipment have been delivered to the ENGINEER.

5. Commissioning has been successfully completed.

6. Punch-list items have been corrected.

7. Record drawings in both hard copy and electronic format have been submitted.

8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.

9. Debris associated with installation of instrumentation has been removed.

10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

- END OF SECTION –

ROTAMETER

INSTRUMENT DATASHEET

FI-111

PLANT NAME

CITY OF EVANSTON

RFQ Number :	
Supply By :	
Install By :	

SPECIFICATION IDENTIFICATIONS	
Document Name	40 91 02.1.xlsx
Latest Revision / Date	
Issue status	New
Project Name	1909 RAW WATER INTAKE REPLACEMENT
Project Number	173440108
WBS Number	NA

PROCESS BASELINE

OPERATING CONDITIONS

* At AVG Operating Temp	Units	Min	Max	Avg
Temperature	°F	0	100	60
Pressure*	psi	0	150	
Flow Rate	gpm	0	130	30
Density	lb/ft³			
Viscosity	cP			
Differential Pressure	psi			
Design Pressure	psi			

OPERATING RANGE

	Units	LRV	URV
Instrument	gpm	0	130
Calibrated	gpm	0	50

PROCESS CONDITIONS

Process Line No	3" CLS (PE05)
Process State	Liquid
Proc Contaminants	
Cp/Cv	VTA
Compressability Z	VTA
Flow Direction	Standard
Area Classification	Unclassified
Skid Number	NA
Surge Arrestor Req	NA

INSTRUMENT BASELINE

Instrument Tag No	**FI-111**
P&ID No	I-5
Service Description	Chlorine feed for 60" Intake
Location	Chlorine Feed System
Ins Type Description	Variable Area Flowmeter (Rotameter)
Operating Principle	Variable Flow
Installation Detail	Per Vendor
Associated Equip	
Location Drawing No	
System	NA
Loop Drawing No	TBD

INSTRUMENT IDENTIFICATIONS

Component	Tag	Model No	Manufacturer	
Flow Indicator	FI-111	**7480 Series**	King Instrument Co	Or Approved Equal

Ordering Note

METER

Process Connection Size	3"	**Float Guide Material**	316L SS
Process Connection Type	Flanged	**End Fitting Materials**	316L SS
Meter Scale Length	10"	**Float Material**	316L SS
Meter Scale Type	Direct Read	**Sight Glass Material**	Borosilicate
Meter Factor	NA	**Mounting Details**	I-106
Meter Scale Range	VTA	**Gasket Material**	Rubber [VTA]
Accuracy	+/- 2 % of Full scale	**Other**	

TRANSMITTER

Power Supply	NA	**Enclosure IP Rating**	NA
Output Signal Type	NA	**Enclosure Material**	NA
Signal Detail	NA	**Enclosure Surface Finish**	NA
Protocol Version	NA	**Mounting Details**	NA
Cable Entry Type (Quan) Size	NA (NA) NA	**Mounting Hardware**	NA
Output Failure Action	NA	**Other**	NA
Accuracy	NA		
Sensor Burnout	NA		

SWITCH

Alarm Contact No.	NA	**Alarm Contact Action**	NA
Alarm Contact Rating	NA	**Alarm Contact Form**	NA
Housing	NA	**Type**	NA
Cable Entry	NA	**Other**	NA

PHYSICAL DATA

Estimated Weight	VTA
Dimensions	VTA
Removal Clearance	VTA
Mfr Ref Drawing	VTA
Meter Scale Length	VTA

SPECIAL REQUIREMENTS

Tag(s)/Plate(s)	Required
Ref Specification	
Compliance Standard	Per Manufacturer
Calibration Report	Required
Hydraulic Calibration	NIST

ACCESSORIES

Valve Type	VTA
Valve Size	VTA
Valve Material	VTA
Purge Meter Tube	Vendor To Supply
Airset	VTA
Sight Glass Protetive Shield	Required, SS

NOTES

1 Vendor Shall Advise on All Fields Labled "VTA". Vendor Shall Confirm All Fields Labeled "VTC".

2

3

Rev	Date	Created By	Approved By	Description	Remarks

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Stantec

DOPPLER FLOWMETER

INSTRUMENT DATASHEET

FT-102

PLANT NAME
CITY OF EVANSTON

RFQ Number :	
Supply By :	
Install By :	

SPECIFICATION IDENTIFICATIONS	
Document Name	40 91 02.1.xlsx
Latest Revision / Date	
Issue status	New
Project Name	1909 RAW WATER INTAKE REPLACEMENT
Project Number	173440108
WBS Number	NA

PROCESS BASELINE

OPERATING CONDITIONS

* At AVG Operating Temp	Units	Min	Max	Avg
Temperature	°F	0	100	60
Pressure *	psi	0	150	
Flow Rate	MGD	0	30	
Velocity	ft/s	0.03	10	
Density	lb/ft³			
Conductivity	uS/cm			
Design Pressure	psi		30	
Design Temperature	°F			60

OPERATING RANGE

	Units	LRV	URV	
Instrument	MGD	0 to 200 MGD		
Calibrated	MGD	0	150	11

PROCESS CONDITIONS

Process Line No	
Process State	Liquid
Proc Contaminants	
Build Up Tendency	
Bi_Directional Flow	No
Area Classification	Unclassified
Skid Number	NA
Surge Arrestor Req	No

INSTRUMENT BASELINE

Instrument Tag No	**FT-102**
P&ID No	I-6
Service Description	60" Intake Doppler Flow Meter
Location	60" Intake Line
Ins Type Description	Pulse Doppler Flow Meter
Operating Principle	Pulse Doppler Velocity Profiling
Installation Detail	I-901
Associated Equip	NA
Location Drawing No	
System	NA
Loop Drawing No	TBD

INSTRUMENT IDENTIFICATIONS

Component	Tag	Model No	Manufacturer	
Transmitter	FT-102	**accQcomm**	TELEDYNE ISCO	OR Approved Equal
Sensor	FE-102	**ADFM PRO20**	TELEDYNE ISCO	OR Approved Equal

Ordering Note

TRANSMITTER

Power Supply	24VDC	**Enclosure IP Rating**	NEMA 4X
Output Signal Type	AI	**Enclosure Material**	316 SS
Signal Detail	4-20mA	**Enclosure Surface Finish**	Epoxy encapsulated
Protocol Version	HART	**Mounting Details**	Installation by Manufacturer
Counduit Entry Quantity/Size	6	**Mounting Hardware**	316 SS
Output Failure Action	Alarm relay output monioring	**Max Cable length to Sensor**	100 ft
Accuracy	±0.5 percent of full scale	**Integral / Remote Mount**	Remote
Repeatability	0.15% of reading ±0.03 ft/s	**Other**	
Number of Channels	VTA		

ELEMENT

Nominal Diameter	60 in	**Sensor IP Rating**	IP 68
Connection Type	Per Manufacturer	**Sensor Type**	Pulse Doppler
Connection Material	316 SS	**Sensor Material**	VTA
Pipe Wall Thickness	NA	**Pipe Material**	VTA
Traverse No (Per Sensor Pair)	NA	**Surface Coating**	VTA
Quantity of Sensors	One (4 velocity beams, 1 level beam)	**Mounting Details**	Installation by Manufacturer
Frequency Output	VTA	**Sensor Cable Material**	PTFE

PHYSICAL DATA

Estimated Weight	VTA
Dimensions	VTA
Removal Clearance	VTA
Mfr Ref Drawing	VTA

SPECIAL REQUIREMENTS

Tag(s)/Plate(s)	Required SS Tag and Cable
Remote/Local Display	Remote
Ref Specification	40_91_00
Compliance Standard	Per Manufacturer
Calibration Report	Required
Testing Required	VTA
Shock/Vib Resistance	VTA

ACCESSORIES

Approx Cable Conn Len (ft)	100
Cable Gland/Conduit Adapter	VTA
Acoustic Coupling Material	Coupling pad by manufacturer
Sound Velocity Sensor	VTA
Wall Thickness Sensor	VTA
Mounting Kit	Permarail Mounting Track IP68 - VTA
Tools	VTA
Tensioning Bands	Required

NOTES

1 Meter Shall Be Installed with a Minimum Straight Pipe Diameters Upstream and Straight Pipe Diameters Downstream as recommended by the manufacturer.

2 Provide 2 days of on-site calibration and testing by a manufacturer's representative

3 Vendor Shall Advise on All Fields Labled "VTA". Vendor Shall Confirm All Fields Labeled With "VTC" Appended.

4 Provide Scissors ring and other installation accessories as recommended by manufacturer.

5 Provide NEMA-4X 316SS enclosure and 24VDC Power Supply.

Rev	Date	Created By	Approved By	Description	Remarks

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Stantec

LEVEL SWITCH

INSTRUMENT DATASHEET

LSH-104

PLANT NAME
CITY OF EVANSTON

RFQ Number :	
Supply By :	
Install By :	

SPECIFICATION IDENTIFICATIONS	
Document Name	40 91 07.1.xlsx
Latest Revision / Date	
Issue status	New
Project Name	1909 RAW WATER INTAKE REPLACEMENT
Project Number	173440108
WBS Number	

PROCESS BASELINE

OPERATING CONDITIONS

* At AVG Operating Temp	Units	Min	Max	Avg
Temperature	°F	0	100	70
Pressure*	psi			
Flow Rate	gpm			
Density	lb/ft³	62	62.5	62.3
Viscosity	cP			
Conductivity	uS/cm			

OPERATING RANGE

	Units	LRV	URV
Instrument	ft	-	
Calibrated	ft	-	

PROCESS CONDITIONS

Proc Line or Tank No	NA
Process State	Liquid
Vibration / Pulsation	
Dielectric Constant	
Foaming / Build Up	
Area Classification	Unclassified
Skid Number	NA

INSTRUMENT BASELINE

Instrument Tag No	**LSH-104**
P&ID No	I-005
Service Description	Valve Vault Sump Level Switch High
Location	Valve Vault Sump Level Switch High
Ins Type Description	Level Switch
Operating Principle	
Installation Detail	I-151
Associated Equip	SP-001
Location Drawing No	
System	NA
Loop Drawing No	TBD

INSTRUMENT IDENTIFICATIONS

Component	Tag	Model No	Manufacturer	
Low Low Level Switch	LSH-104	T10	Magnetrol	or Approved Equal

Ordering Note

SENSOR

Process Connection Size	NA	**Process Connection Rating**	NA
Process Connection Type	Support Pipe	**Connection Material**	NA
Reference Probe Required	No	**Gasket Material**	Neoprene (Strain Relief)
Element Type	Suspended Float	**Element Material**	UV stable PVC / PPE
Element Length	NA	**Cable Length**	50 ft
Insertion Depth	To Be Confirmed Based on Vendor Data	**Cable Type / Material**	Integral / PVC
Tank Port ID	NA	**Grounding**	

SWITCH

Power Supply	NA	**Enclosure Rating**	IP68
Output Signal Type	DI	**Enclosure Material**	UV stable PVC / PPE
Signal Detail	120 VAC	**Mounting Details**	Per Manufacturer
Contact Type (Quan) Rating	SPDT N.O (1) 14A @ 30Vdc	**Mounting Hardware**	316 SS
Cable Entry Type (Quan) Size	Conduit (1) 1/2" NPT(F)	**Adjustable Setpoint Range**	TBD
Accuracy	NA	**Setpoint**	NA
Deadband Type	Narrow Adjustable		

PHYSICAL DATA

Estimated Weight	VTA
Dimensions	VTA
Removal Clearance	VTA
Mfr Ref Drawing	VTA
Active Elevation	To Be Verified In Field

SPECIAL REQUIREMENTS

Tag(s)/Plate(s)	Required SS Tag and Cable
Ref Specification	
Compliance Standard	Per Manufacturer
Calibration Report	NA

ACCESSORIES

Cable Glands	Vendor To Supply
Terminal Box	Furnished & Installed By Contractor
Supports	Furnished & Installed By Contractor

NOTES

1 Vendor Shall Advise on All Fields Labled "VTA". Vendor Shall Confirm All Fields Labeled With "VTC" Appended.

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Rev	Date	Created By	Approved By	Description	Remarks

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Stantec

TEMPERATURE TRANSMITTER

INSTRUMENT DATASHEET

TT-101

PLANT NAME
CITY OF EVANSTON

RFQ Number :	
Supply By :	
Install By :	

SPECIFICATION IDENTIFICATIONS	
Document Name	40 91 10.1.xlsx
Latest Revision / Date	
Issue status	
Project Name	1909 RAW WATER INTAKE REPLACEMENT
Project Number	173440108
WBS Number	

PROCESS BASELINE

OPERATING CONDITIONS

* At AVG Operating Temp	Units	Min	Max	Avg
Temperature	°F	0	100	60
Pressure*	psi	0	150	
Flow Rate	MGD	0	30	
Velocity	ft/s	0.03	10	
Density	lb/ft³			
Viscosity	cP			
Ambient Temp	°F			60
Vapor	Cp/Cv			

OPERATING RANGE

	Units	LRV	URV
Instrument	°F	0	100
Calibrated	°F	0	100

PROCESS CONDITIONS

Process Line No	
Process State	Liquid
Proc Contaminants	NA
Build Up Tendency	NA
Area Classification	Unclassified
Skid Number	
Surge Arrestor Req	No
Weather Shield Req	Yes

INSTRUMENT BASELINE

Instrument Tag No	**TT-101**
P&ID No	I-6
Service Description	Lake Intake Water Temperature
Location	60" Intake
Ins Type Description	RTD
Operating Principle	Temperature
Installation Detail	Vendor
Associated Equip	
Location Drawing No	
System	NA
Loop Drawing No	TBD

INSTRUMENT IDENTIFICATIONS

Component	Tag	Model No	Manufacturer	
Temperature Indicating Transmi	TT-101	**TS100**	PMC	Or Approved Equal
Temperature Element	TE-101	**Integral to Transmitter**	PMC	
Thermowell	NA			

Ordering Note

TRANSMITTER / HEAD

Power Supply	Loop	**Enclosure IP Rating**	IP67
Output Signal Type	AI	**Enclosure Material**	316 SS
Signal Detail	4-20mA (HART)	**Enclosure Surface Finish**	Powder Coated
Protocol Version	NA	**Mounting Details**	Per Vendor
Cable Entry Type (Quan) Size	Conduit (1) 1/2" NPT(F) [VTC]	**Mounting Hardware**	VTA
Output Failure Action	Digital Alarm	**Terminal Block**	VTA
Accuracy	± 2°F	**Nipple/Union**	VTA
Repeatability	± 1% of Reading	**Screwed Cap & Chain**	NA
Head Style	VTA	**Other**	

ELEMENT

Connection Type	Threaded ½" NPT(M)	**Lead Wires**	NA
Element Material	VTA	**Lead Wire Length**	NA
Element Style	Wire Wound	**Element Insulated Material**	VTA
Sheath Outter Diameter	X mm [VTA]	**Insertion Length**	VTA
Sheath Material	316 SS [VTC]	**Mounting Thread**	VTA
Ice Point Resistance	VTA	**Mounting Details**	VTA

WELL

Process Connection Size	NA	**Construction Type**	NA
Process Connection Type	NA	**Process Connection Material**	NA
Element Connection	NA	**Well Material**	NA
Bore Diameter	NA	**Well Lining**	NA
Outside Diameter	NA	**Insertion Length**	NA
Tapered Length	NA	**Total Length**	NA
Tip Thickness	NA		

PHYSICAL DATA

Estimated Weight	VTA
Dimensions	VTA
Removal Clearance	VTA
Mfr Ref Drawing	VTA

SPECIAL REQUIREMENTS

Tag(s)/Plate(s)	Required
Ref Specification	
Compliance Standard	Per Manufacturer
Calibration Report	Required
Hydrostatic Testing	Required
Certification	Required

ACCESSORIES

Connecting Cable Length (ft)	6000 ft
Cable Glands	NA
Moisture Seal	VTA
Bayonet Adapter	VTA
Additional Fittings	VTA
Local Display / Scale	Not Required

NOTES

1 Provide 6000ft vendor cable coiled on a reel.

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Rev	Date	Created By	Approved By	Description	Remarks

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SECTION 40 95 13 - CONTROL PANELS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. General: The CONTRACTOR shall provide the PLC panels and the Local Control Panels (LCP), complete and operable, in accordance with the CONTRACT Documents. The Local Control Stations (LCS) are supplied under Division 26.

B. Reference the typical panel layout drawings Bill of Material for panel hardware requirements.

C. The requirements of Section 40 91 00 – Process Control and Instrumentation apply to this Section.

D. The provisions of this Section apply to local control panels provided in equipment systems specified in other sections unless indicated otherwise in those sections.

1.2 SUBMITTALS

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

B. Control Panel Engineering Submittal: The CONTRACTOR shall submit a Control Panel Engineering Submittal (CPES) in hard and electronic copy for each control panel and enclosure provided under Division 40. The CPES shall completely define and document the construction, finish, layout, power circuits, signal and safety grounding circuits, fuses, circuit breakers, signal circuits, internally-mounted instrumentation and SCADA system components, faceplate-mounted instrumentation components, internal panel arrangements, and external panel arrangements. Panel drawings shall, as a minimum, be "B" size with data sheets and manufacturer specification sheets being "A" size. The submittal shall be submitted as a singular complete bound volume or multi-volume package and shall have the following contents:

1. A complete index shall appear in the front of each bound volume. Drawings and data sheets associated with a panel shall be grouped together with the panels being indexed by systems or process areas. Panel tagging and nameplate nomenclature shall be consistent with the requirements of the CONTRACT Documents.

2. Schematic/elementary diagrams shall depict control devices and circuits and their functions.

3. Wiring/connection diagrams shall locate and identify electrical devices, terminals, and interconnecting wiring. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of electrical and control devices.

4. Interconnection diagrams shall locate and identify external connections between the control panel/control panel devices and associated equipment. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical locations of panel ingress and egress points.

5. Scale construction drawings which define and quantify the type and gauge of steel to be used for panel fabrication, the ASTM grade to be used for structural shapes and straps, panel door locks and hinge mechanisms, type of bolts and bolt locations for section joining and anchoring, details and proposed locations for "UNISTRUT" members, stiffener materials and locations, electrical terminal box and outlet locations, electrical access locations, print pocket locations, writing board locations, and lifting lug material and locations.

6. Scaled physical arrangement drawings drawn to scale which define and quantify the physical groupings comprising control panel sections, auxiliary panels, subpanels, and racks. Cutout locations with nameplate identifications shall be shown.

7. The detailed panel design shall include cabinet sizing for SCADA Growth Provisions and thermal management requirements. The panel drawings in the CONTRACT Documents serve as the general arrangement of hardware, the CONTRACTOR is responsible for final panel size to accommodate all the required hardware, spare hardware and future space requirements as defined in Section 26 05 15. The CONTRACTOR shall coordinate the housekeeping pads are properly sized to accommodate the final panel size.

8. Front of panel layouts for control panels.

9. All Panel heat rise calculations shall be submitted for approved before panel construction begins

10. A bill of material which enumerates devices associated with the control panel.

11. Catalog cuts with model numbers, sizes, options, etc. shall be submitted for the enclosure and ALL components mounted on or inside the enclosure.

12. NOTE: Submittals that do not meet the requirements of Section 40 91 00 – Process Control and Instrumentation to identify all components, model number, sizes, ranges, ratings, options, spare parts, etc. with a red arrow, high-lighted text or other acceptable identifying method will be rejected without an ENGINEER review.

C. Control Panel Record Documentation: On successful completion of site acceptance test, the CONTRACTOR shall provide all “As-Built” documentation and drawings in hard and electronic copy. All final and field mark-ups shall be incorporated electronically. Hand-written revisions are not acceptable. Final documentation must include the following:

1. Index.

2. Wiring diagrams including all wire and terminal numbers.

3. Wiring schedules and interconnection diagrams.

4. Panel layouts.

5. Parts list or bill of materials showing tag number or identifier, quantity, make, model number, and description for panel and all components and devices.

6. Installation drawings.

7. Installation, operation & maintenance manuals.

8. All information, including panel weight, power supply requirements, etc. necessary for installation of the control panel(s).

9. Test and completion certificates.

10. Operating characteristics of fuses and circuit breakers (manufacturer's technical data sheets).

11. Size and weight of all shipping containers.

1.3 EXTENDED PERIOD FOR CORRECTION OF DEFECTS

A. The CONTRACTOR shall correct defects in accordance with Section 40 91 00 – Instrumentation and Control Systems.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Control panels shall be housed in 316 stainless steel NEMA 12 enclosures unless otherwise defined under this section. Control panels shall be freestanding, single access, double door enclosure as indicated on the drawings. Internal control components shall be mounted on an internal back-panel or side-panel as required. Provide all electrical components and devices, support hardware, fasteners, and interconnecting wiring as required for a complete and operational.

B. Environmental Suitability: Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the CONTRACT Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide power wiring for these devices. Enclosures suitable for the environment shall be provided. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

C. The control panel controls shall be 24 VDC or 120 VAC as indicated on the CONTRACT Documents. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3 phase, the control panel shall be provided with a control transformer. Control conductors shall be provided in accordance with the indicated requirements.

D. The control panel shall be the source of power for devices interconnected with the control panel. Equipment associated with the control panel shall be ready for service after connection of conductors to equipment, controls, and control panel.

E. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3 phase, the main feeder disconnect shall have a door-mounted handle with a defeat mechanism unless otherwise indicated.

F. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use.

G. All PLC I/O spares shall be fully pre-wired from the I/O terminations to the panel side of interposing terminals. (The other side of the interposing terminals is reserved for field terminations).

H. Control panel mounted devices shall be mounted a minimum of 3-feet above finished floor elevation.

I. Locate and install all devices and components so that connections can be easily made and so that there is ample room for servicing or replacing each item.

J. Adequately support and restrain all devices and components mounted on or within the panel to prevent any movement.

K. Provide sub-panels for installation of all terminals, fuses and other internally mounted components.

L. The panel shall be sized to accommodate the SCADA Growth Provisions and thermal management requirements. See paragraph 1.02-B.7 for panel size requirements.

M. Panel shall be equipped with door(s) for front of panel opening and as indicated on the CONTRACT Documents. 25 percent spare space requirement also applies to the front of panel.

N. All vendor-supplied Vendor Control Panels (VCP) shall conform to all of the requirements of this specification.

O. CONTRACTOR shall be responsible for the detailed layout and design of the panels in accordance with standard practice and techniques and local and national codes and requirements. The actual layout shall be subject to approval by ENGINEER.

P. Panel shall be UL approved and meet applicable UL standards including, but not limited to, UL 508 Standard for Industrial Control Equipment) UL508A (Standard for Industrial Control Panels).

Q. Panel shall meet applicable sections of the latest edition of the NEC including, but not limited to, Article 409 Industrial Control Panels. Provide calculation and/or method for determining short-circuits current rating.

R. All panels, materials and equipment shall be new and shall be built in an Underwriters Laboratory (UL) approved panel shop and bear the UL label.

2.2 PANEL CONSTRUCTION REQUIREMENTS

A. Panels shall be unpainted, 316 stainless steel with a smooth brushed finish and a NEMA 4X rating.

1. Mounting sub-panels to be 12 gage 316 stainless steel.

2. Oil-resistant, seamless door gasket.

3. All panel penetrations shall be sealed and maintain the NEMA panel rating.

4. Any panel or door mounted devices (e.g., pushbutton, pilot light, OIT) or instruments shall have a NEMA 4X rating.

B. Floor-mount panels shall be minimum 12-gauge for all surfaces.

1. Seams continuously welded and ground smooth.

2. Remove corrosion, burrs, sharp edges, and mill scale.

3. No holes or knockouts unless otherwise specified.

4. Removable heavy gauge continuous stainless steel door hinges.

5. Provide 12-inch floor stands for the enclosure unless otherwise specified. Floor stands shall match the associated panel gauge and material.

6. Rolled flanges around three sides of door and all sides of enclosure opening to exclude liquids and contaminants.

7. Overlapping doors or removable center post.

8. Body stiffeners and panel supports as required.

9. Provide handle-operated, oil-tight, key-lockable three point stainless steel latching system with rollers on latch rods for easy door closing for control room panels.

10. Data pocket mounted inside panel on door(s).

11. Ground studs in body of enclosure.

12. Bonding provision on doors.

13. Lifting eyes, as required. .

14. Bottom 12 inches of panels shall be free of all devices, including terminal strips, to provide ease of installation and testing.

15. No device mounted on a surface or door of the panel shall be mounted less than 36 inches above the operating floor level unless otherwise specified.

C. Frame or wall-mounted panels shall be minimum 14-gauge for all surfaces.

1. Seams continuously welded and ground smooth.

2. Remove corrosion, burrs, sharp edges, and mill scale.

3. No holes or knockouts unless otherwise specified.

4. Removable heavy gauge continuous stainless steel door hinges.

5. External wall-mounting brackets.

6. Rolled flanges around three sides of door and all sides of enclosure opening to exclude liquids and contaminants.

7. Stainless steel quick release screws and clamps on three sides of each door.

8. Hasp and staple for padlocking.

9. Data pocket mounted inside panel on door(s).

10. Oil-resistant, seamless foam-in-place door gasket.

11. Ground studs in body of enclosure.

12. Bonding provision on doors.

D. Panels Serving Equipment in Hazardous (Classified) Locations

1. Conduit and wire between panels and Class 1, Division 1 or 2 areas shall be installed per the requirements of the NEC.

2. CONTRACTOR shall also meet hazardous area requirements through means such as the use of panel mounted intrinsic safety barriers.

2.3 ENVIRONMENTAL CONTROL

A. For control panels located in non-environmentally controlled areas, provide 120 VAC thermostatically controlled strip heaters inside panels, as required to maintain panel temperature 10° F above ambient to prevent condensation within panel.

B. Provide heat calculations for each panel or enclosure to verify that there is sufficient dissipation of generated heat to maintain interior panel temperature and humidity within 20% of the maximum and minimum operating parameters of all panel components.

C. Provide automatically-controlled closed-loop ventilation fans or closed- loop air conditioners with filtered air louvers, if required, to maintain temperature and humidity inside each enclosure 20% below the maximum operating temperature rating of the components inside.

D. Provide thermostatic control for automatic changeover from heating to cooling without the need for manual intervention.

E. The CONTRACTOR shall provide all internal power wiring and circuit protection for the panel environmental control equipment.

2.4 ELECTRICAL REQUIREMENTS

A. Power Source and Internal Power Distribution

1. Panel power supply voltage, breaker size (in amps), power panel identification, and circuit number shall be shown on the Drawings.

2. The panels shall be provided with an internal 120 VAC power distribution with separate circuit breakers, sized as required, to distribute power. Provide circuit breakers for 24 VDC instruments with no more than six devices on a single circuit. Provide 20% spare (minimum of five) installed breakers or fused terminations for each type and voltage level, and provide space for 25% more (in addition to the 20% spare installed).

3. All 120 VAC instrument power circuits shall be protected by separate **Allen Bradley 1492-H series** fused terminal blocks.

4. When DC power and/or low voltage AC power is required, provide, install, and wire the necessary power supplies and transformers in the panel. For example, all panels shall have a 24 VDC power supply wired to power analog signals that are not otherwise powered.

B. Convenience Accessories

1. One 120 VAC, 20 A, duplex, grounding type receptacle.

2. 120 VAC fluorescent light fixture(s) with shielding and filtering to minimize EMI. Lamp wattage (minimum 20 W) and number of fixtures suitable for sufficient illumination of entire panel.

3. One 120 VAC, 20A door switch for panel light fixture(s), mounted in a metal outlet box with a metal cover. Locate in an area easily accessible from access door.

4. The light fixture(s) and duplex receptacle shall have its own circuit breaker wired to separate terminals for separate 120 VAC service.

C. Wiring and Termination

1. All wiring to panel connections from field instruments, devices, and other panels shall be terminated at master- numbered terminal strips, unless otherwise specified.

2. Splicing of conductors or cables is not permitted.

3. Provide copper ground bar for all panel equipment.

4. Internal wiring shall be Type THHN/THWN dual rated, stranded copper wire with thermoplastic insulation rated for 600 V at 90 C for single conductors, color coded and labeled with wire identification.

5. For internal panel DC signal wiring, use shielded, minimum No. 18 AWG. For DC field signal wiring, terminal strips shall be capable of handling minimum No. 12 AWG wiring.

6. For internal panel AC power wiring, use minimum No. 12 AWG. For AC signal and control wiring, use minimum No. 16 AWG. For wiring carrying more than 15 amps, use sizes required by the NEC.

7. Separate and shield DC signal wiring from power and control wiring by a minimum of 12 inches. Design to avoid DC and power/control wiring from crossing each

other. If a crossing cannot be avoided, then the crossing shall be at right angles. See Table 2.4 – Separation Distances.

8. Group or bundle parallel runs of wire using covered wire-way. Maximum bundle size to be 1 inch. Wire-way shall have 50 percent spare design capacity.

9. Install wire wire-way along horizontal or vertical routes to present a neat appearance. Angled runs are not acceptable.

10. Mount wire wire-way parallel to terminal strips. Provide adequate spacing, with a 4" minimum, in order to read wire identification tag without opening wire trough or moving any wires or panel components.

11. Rear panel-mounted (sub-plate) equipment such as loop power supplies, receptacles, surge protection devices, media converters, etc. shall be mounted on **Allen-Bradley 1492-DR5** standard DIN rail.

12. Adequately support and restrain all wiring runs to prevent sagging or other movement.

13. All wiring shall be installed such that if wires are removed from any one device, power will not be disrupted to any other device.

14. Provide and install spare terminal blocks in accordance with Section 26 05 15. Provide a separate terminal for grounding each shielded cable.

15. Use separate 5/16-inch diameter copper grounding studs for instrument signal cable shields and AC power.

16. Where wires pass through panel walls, provide suitable bushings to prevent cutting or abrading of insulation. Penetrations to be sealed according to panel NEMA rating and environmental requirements.

17. Conduit entry shall be made in bottom of control panels furnished under Division 40. Conduit entries in the side or top of control panels are not acceptable. Reference 26 05 33 - Electrical Raceway Systems for conduit and conduit fitting requirements.

18. Provide complete wiring diagram showing "as built" circuitry. All revisions must be done in CAD—no hand-written revisions allowed. Diagram shall be enclosed in transparent plastic and placed in easily accessible pocket built into panel door.

19. Control panels shall comply with applicable requirements of Division 26 Electrical Specifications.

D. Low-Voltage Power Distribution Terminal Blocks

1. Provide copper power distribution blocks for low-voltage circuits sized to meet application. Provide **Square D Class 9080-LBC Series**, or approved equal. Provide clear plastic covers for terminal blocks to prevent incidental contact with terminals.

E. Terminal Blocks

1. Terminate all field wiring and internal panel wiring at screw type, feed-through, finger safe terminal blocks. Provide gray terminal blocks unless otherwise specified or shown on drawings. Provide **Allen-Bradley Catalog number series 1492-J*** or approved equal. Adjust catalog number for wire sizes used. For example, for wire size range from 22 AWG to 10 AWG use **Allen-Bradley Catalog No. 1492-J4**, or approved equal.

2. Terminal blocks shall be UL/CSA approved with a 300 volt rating.

3. Mount non-fused terminal blocks on high-rise DIN rail, **Allen-Bradley 1492-DR6**.

4. Heavy-duty end anchors shall be provided on both ends of all terminal strips to firmly anchor the terminal blocks to the mounting rail and insulating end barriers shall be provided on one end of the terminal strip, as necessary.

5. No more than two wires shall be terminated at any single screw. Provide jumpers as required to join adjacent terminal blocks for additional wiring connection points.

6. All terminal blocks shall be labeled with alpha or numeric identifiers on each block. Identifiers shall be pre-printed snap-in marker cards.

7. Provide a separate terminal block for landing each analog signal cable shield.

8. Provide separate terminal strips with minimum physical separation for DC signal and AC power wiring. Maintain minimum physical separation between signal and power wiring. See Table 2.4 – Separation Distances.

TABLE 2.4 - SEPARATION DISTANCES

Voltage	**Current**	**Minimum Distance Between AC Power Wiring and Signal Wiring**
0 to 125 volts	0 to 10 amps	12 inches
125 to 250 volts	1 to 50 amps	15 inches
250 to 480 volts	0 to 200 amps	18 inches

F. Fused Terminal Blocks

1. Provide screw type, fused terminal blocks for all wiring powered from within panels or enclosures or to devices located outside the panel or enclosure. Provide black terminal blocks unless otherwise specified or shown on drawings. Fused terminal blocks shall be **Allen-Bradley Cat. No. 1492-H***, or approved equal with blown fuse indication (LED preferred when available). For example, for 1/4" x 1 – 1/4" fuse size and 10 to 57 V AC/DC service use **1492-H5** with LED indicator and for 100 to 300 V AC service use **1492-H4** with Neon indicator or approved equal.

2. Fused terminal blocks shall be UL/CSA approved with a minimum 300 volt rating.

3. Mount fused terminal blocks on high-rise DIN rail, **Allen-Bradley 1492-DR6**.

4. Heavy-duty end anchors shall be provided on both ends of all terminal strips to firmly anchor the terminal blocks to the mounting rail and insulating end barriers shall be provided on one end of the terminal strip, as necessary.

5. No more than two wires shall be terminated at any single screw. Provide jumpers as required to join adjacent terminal blocks for additional wiring connection points.

6. All terminal blocks shall be labeled with alpha or numeric identifiers on each block. Identifiers shall be pre-printed snap-in marker cards.

7. Provide separate terminal strips with minimum physical separation for DC signal and AC power wiring. Maintain minimum physical separation between signal and power wiring. See Table 2.4 – Separation Distances.

8. Provide fuses (sized as required) and fuse pullers for all fused terminal blocks.

9. Provide 20 percent spare fused terminal blocks mounted on the rail(s). Wire all spares from I/O card termination arms to the fused terminal blocks.

G. EMI / RFI Protection

1. Construction and design techniques shall be used to minimize EMI / RFI. Use shielding, physical separation, filters, ferrite beads, or other methods to insure no interference to or from electrical or battery-operated components or devices.

H. Surge Protection

1. General: Surge protection shall be provided to protect the electronic instrumentation system from surges propagating along the signal and power supply lines. The protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring. Instruments shall be housed in suitable metallic cases, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and where practical each ground wire run individually and insulated from each other. These protectors shall be mounted within the instrument enclosure or a separate junction box (compatible with the area designation) coupled to the enclosure.

2. Provide formal lightning and surge protection devices for all signal lines, communication networks, and power feeds for SCADA equipment. For signal lines, communication networks, and power feeds to control panels, PLC panels and SCADA equipment, provide formal lightning and surge protection devices for all lines that originate or are routed outside a building on any part of the existing or proposed circuits, either in buried or exposed raceways.

3. Lightning and surge protection devices shall be standard manufactured products comprising multi-component networks or hybrid circuits. The units shall incorporate gas filled discharge tubes, metal oxide varistors, and/or Zener diodes providing full protection from line to line and from line to ground. Units shall be DIN-rail mounted, rated for a minimum 10kA maximum surge current and voltage suitable for the type of circuit being protected. Reaction time shall be on the order of nanoseconds.

4. Surge protection for signal lines shall be **SD Series, as manufactured by MTL**, or approved equal.

5. Surge protection for communication lines shall be **Zonebarrier Series, as manufactured by MTL**, or approved equal.

6. For AC power lines use UL 1449, minimum 40kA surge protection, model **EMC-240B** from **Emerson (Edco)**, or approved equal.

I. Intrinsically Safe Barrier

1. The barrier shall provides a fully-floating DC supply for energizing a conventional 2-wire 4/20mA transmitter, which is located in a Class 1 Division 2 Group D hazardous area, and repeats the current in another floating circuit to drive a safe-area load. The barrier shall be HART compatible and allows bi-directional communications signals superimposed on the 4/20mA loop current. Intrinsically safe barrier shall be a **model MTL4541** or approved equal. Reference the Instrument List for field devices requiring intrinsically safe barriers.

J. Control Panel 24 VDC Power Supplies

1. Control panels shall be provided with redundant power supplies which shall be configured in a fault-tolerant manner to prevent interruption of service upon failure and interruption of service necessitated by the replacement of a power supply.

2. The CONTRACTOR shall size the power supplies to meet the control panel requirement and the instruments and loops they support. Power supplies shall have an excess rated capacity of 40 percent. The failure of a power supply shall be alarmed at the DCS.

3. Power Supplies – 24 VDC: The control and DCS panels shall be the source of power for any 24 VDC two-wire field device, devices in the panel requiring 24 VDC power, or where applicable, solenoid valves interconnected with the panel.

4. The failure of a power supply shall open a dry relay contact output that can be used as an input to the DCS.

5. **Power supplies shall be Phoenix Contact 24 VDC Quint series, or equal.**

2.5 CONTROL / TIMING RELAYS

A. Type: General purpose, plug-in type rated for continuous duty.

1. All relay and timer sockets shall be mounted on standard DIN rail, **Allen-Bradley 1492-DR5**.

B. Performance and Construction Requirements:

1. Coil Voltage: 120 VAC or 24 VDC, as required.

2. Contact Configuration: Minimum DPDT with at least one spare contact. If 4PDT relay is required, see Item 4, below.

3. Contact Material and Rating:

    a. General Use: Silver or silver cadmium oxide contacts rated for 10 amps minimum (DPDT) at 120 VAC.

    b. Low Power Switching: Fine silver, gold flashed contacts specifically designed for low power switching, rated for 2 amps minimum at 30 VDC. Idec series RY or approved equal. Consult the ENGINEER.

4. Mounting: 8-Pin or 11-pin octal base plug-in sockets for sub-panel mounting on standard DIN rail. Sockets shall have screw terminals for wiring connections which shall accept a minimum of two #14 AWG wires. (Four pole relays as in paragraph #4, below, shall be supplied with a matching blade-style socket.)

5. Cover: Clear plastic dust cover.

6. Finger-safe terminals.

7. Indication: LED indicator light.

8. Accessories: Hold-down spring or clip.

9. Accessories: MOV for DC voltage coil and MOVs for contacts, as required.

10. Accessories: MOV or Zener diode for AC voltage coil, MOVs for contacts, as required.

11. Approvals: UL recognized.

12. Manufacturer and Model:

    a. **Tyco / Potter & Brumfield KRPA Series.**

    b. **Allen-Bradley 700-HA Series**

    c. **Magnecraft / Struthers-Dunn 750 Full-featured Series**

    d. Or approved equal.

13. Manufacturer and Model (If 4PDT relay required):

14. The following relays come with blade-style terminals:

    a. **IDEC RH4B Series**.

    b. **Magnecraft / Struthers-Dunn 782XDX Full-featured Series.**

    c. **Allen-Bradley 700-HC2 Series.**

    d. **Square D 8501RS Series.**

e. Or approved equal.

15. Type: Programmable, multi-function, multi-range plug-in type time delay relay providing delay-on-make, delay-on-break and interval operation. Time shall be adjusted with a thumbwheel or digital display and not a rotary knob.

16. Construction Features:

    a. Time range: 0.1 seconds or less to 9990 hours or more.

    b. Digital setting accuracy: Five percent or better.

17. Contacts:

    a. Type: DPDT

    b. Rating: 10 Amp minimum

18. Housing: Plug-in design with dust and moisture-resistant molded plastic case.

19. Power input: 24 to 240 V AC or DC.

20. Operating Temperature: -10º C to +55º C.

21. Unit shall have LEDs or LCD to show timing status.

22. Finger-safe terminals.

23. Hold-down clips.

24. Suppression diode or current snubber, as required

25. Approvals: UL recognized.

26. Manufacturer and Model:

    a. **Magnecraft TDRPRO 5100 Series**

    b. **Tyco / Potter & Brumfield CNT-35-96**

    c. Or approved equal.

2.6 PANEL-MOUNTED OPERATORS and PILOT LIGHTS

A. Pushbuttons – General Purpose Areas

1. 30 mm NEMA 4X/13 watertight & oil tight.

2. Non-illuminated.

3. Momentary contact unless otherwise specified.

4. 1 N.O & 1 N.C. contact unless otherwise specified.

5. Standard aluminum, grey legend plate unless otherwise specified.

6. Nameplate, white letters on black; text as specified.

7. Reference Table 2.6-1 for operator color requirements.

8. Manufacturer and Model:

    a. **Allen-Bradley 800H Series**

    b. Or approved equal

B. Pushbuttons – Hazardous (NEC classified) Locations

1. 30 mm NEMA 7/9 for Division 1 and Division 2 Areas.

2. Non-illuminated.

3. Momentary contact unless otherwise specified.

4. 1 N.O & 1 N.C. contact unless otherwise specified.

5. Standard aluminum, grey legend plate otherwise specified.

6. Nameplate, black letters on white; text as specified.

7. Reference Table 2.6-1 for operator color requirements.

8. Manufacturer and Model:

    a. **Allen-Bradley 800H Series**

    b. Or approved equal

TABLE 2.6-1 OPERATOR COLOR

Function	Style	Operator Color
Start	Flush	Green
Stop	Extended	Red
Emergency Stop	Mushroom	Red
All Other Functions*	Flush	Black

*Unless otherwise specified.

C. Pilot Lights – General Purpose Areas

1. 30 mm NEMA 4X/13 watertight and oil tight.

2. Full voltage, LED lamp, push-to-test.

3. Voltage to match application.

4. Standard aluminum, grey legend plate unless otherwise specified.

5. Nameplate, black letters on white, text as specified.

6. Reference Table 2.6-2 for lens color requirements.

7. Manufacturer and Model:

    a. **Allen-Bradley 800H Series**

    b. Or approved equal

D. Pilot Lights – Hazardous (NEC classified) Locations

1. 30 mm NEMA 7/9 for Division 1 and Division 2 Areas.

2. Full voltage, LED Lamps, push-to-test.

3. Voltage to match application.

4. Standard aluminum, grey legend plate unless otherwise specified.

5. Nameplate, black letters on white, text as specified.

6. Reference Table 2.6-2 for lens color requirements.

7. Manufacturer and Model:

    a. **Allen-Bradley 800H Series**

    b. Or approved equal

TABLE 2.6-2 LENS COLOR

Function	Color	Examples
Power	White	Panel power on, control power on
Status	Blue	In remote, In calibration
Alarm or Fault	Amber	VFD fault, low level, high pressure
Energized	Red	Motor or pump running, valve open
De-Energized	Green	Motor or pump stopped, valve closed

E. Selector Switches – General Purpose Areas

1. 30 mm NEMA 4X/13 watertight and oil tight.

2. Non-illuminated.

3. Number of positions to suit application.

4. Maintained or spring return to suit application.

5. 2 N.O. and 2 N.C. contacts unless otherwise specified.

6. Standard knob lever with black knob and white insert unless otherwise specified.

7. Standard aluminum, grey legend plate unless otherwise specified.

8. Nameplate, black letters on white, text as specified.

9. Manufacturer and Model:

    a. **Allen-Bradley 800H Series**

    b. Or approved equal

F. Selector Switches – Hazardous (NEC classified) Locations

1. 30 mm NEMA 7/9 for Division 1 and Division 2 Areas.

2. Non-illuminated.

3. Number of positions to suit application.

4. Maintained or spring return to suit application.

5. 2 N.O. and 2 N.C. contacts unless otherwise specified.

6. Standard knob lever with black knob and white insert unless otherwise specified.

7. Standard aluminum, grey legend plate unless otherwise specified.

8. Nameplate, black letters on white, text as specified.

9. Manufacturer and Model:

    a. **Allen-Bradley 800H Series**

    b. Or approved equal.

2.7 IDENTIFICATION

A. Provide laminated plastic nameplates for identification of panels and its components. Nameplates shall be 3/32-inch thick laminated phenolic type with white matte finish and black letter engraving. Nameplates shall be attached to the panel face with two stainless steel self-tapping screws.

1. Panel identification nameplates to have 1/2-inch high letter engravings.

2. Panel-mounted component (i.e., control devices, indicating lights, selector switches, instruments, etc.) identification nameplates to have 3/16-inch high letter engravings. Include legend plates for items like push buttons, pilot lights and selector switches to show indication or position function (e.g., ON or HAND-OFF-AUTO).

3. Nameplate engravings shall include the instrument or equipment tag number and descriptive title as shown and specified.

B. Tag all front of panel-mounted components and internally-mounted components in accordance with the following requirements:

1. Tag numbers shall be as defined in the CONTRACT Documents, drawings, data sheet, or specifications and as provided herein by the ENGINEER.

2. The identifying tag number shall be permanently etched or embossed onto a stainless steel tag securely fastened to the device housing.

3. Where neither of the above fastenings can be accomplished, tags shall be permanently attached to the device by a circle of 1/16-inch diameter stainless steel wire rope.

4. Identification tags shall be installed so that numbers are easily visible to service personnel.

5. Front of panel mounted components shall have the tag attached to rear of device (in addition to the front of panel nameplate).

C. Label internally mounted components and devices (e.g., power supplies, power distribution blocks), mounting rails (e.g., for terminal blocks), etc. with phenolic nameplates attached with self-tapping stainless steel screws or adhesive or with other approved method. Attach to mounting plate or panel surface near the device in a manner that makes identification unambiguous. Manufacturer-provided identification means are acceptable if approved by the ENGINEER.

D. Tagging of the following items shall be accomplished with the use of machine-generated adhesive plastic labels **by W.H. Brady**, or equal.

1. Tag all electrical devices (circuit breakers, relays, timers, etc.) mounted within control panels and enclosures. Do not cover model numbers or other text or indicating lights.

2. Numerically tag individual terminals or terminal blocks (pre-printed push-on plastic labels from vendor may be used).

3. Color code and numerically tag wiring at each end according to drawings or other documents, as applicable.

4. Tag all pneumatic lines.

PART 3 -- A. EXECUTION

3.1 INSTALLATION

A. Preparation for Shipment and Shipping

1. Panels shall be crated for shipment using a heavy framework and skids. Panel sections shall be cushioned to protect the finish of the instruments and panel during shipment. Instruments that are shipped with the panel shall have suitable shipping stops and cushioning material installed to protect parts that could be damaged due to mechanical shock. Each separate panel unit shall be provided with removable lifting lugs to facilitate handling.

2. Shipments shall be by air ride van unless otherwise indicated.

3. Control panel testing and inspection shall be performed prior to shipping.

4. Control panels shall be installed in accordance with Section 26 00 00 – Electrical Work, General and the General Electrical Standard Details.

3.2 CONTROL PANEL SIGNAL AND CONTROL CIRCUIT WIRING

A. Wiring Installation: Wires shall be run in plastic wireways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, (3) wiring from components on a swing out panel to components on a part of the fixed structure, and (4) wiring to panel-mounted components. Wiring run from components on a swing out panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the hinge loop so that conductors are not strained at the terminals.

B. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.

C. Wiring to rear terminals on panel-mount instruments shall be in plastic wireways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

D. Shop Drawings shall show conformance to the above wiring installation requirements.

E. Wire Marking: Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on Shop Drawings. These numbers shall be marked on conductors at every terminal. Pre-printed self-sticking labels for coding all wiring shall be as manufactured by W.H. Brady, 3M, or approved equal. No hand-written labels are permitted.

3.3 CALIBRATION, TESTING, AND INSTRUCTION

A. General: Calibration, testing, and instruction shall be performed in accordance with Section 40 91 00 - Process Control and Instrumentation.

B. Inspection and Testing

1. All panels, consoles, and cabinets shall be inspected by the CONTRACTOR. Inspection shall include, but not be limited to, the following:

a. Nameplates, warning labels, and tags including correct spelling, color and size of labeling and characters.

b. Enclosure flatness, finish, and color.

c. Proper operation of doors, catches, and locks.

d. Wire types, sizes, and colors.

e. Proper wiring layout, practices and grounding.

f. All electrical circuits checked for continuity.

g. Terminal block contact ratings and numbers.

h. Terminal block, fuse, breaker, & other required installed spares.

i. General arrangement and space allocation.

j. AC/DC power checks.

k. Power fail/restart tests.

l. Diagnostic checks.

m. All electrical circuits energized simultaneously and continuously for 48 hours without failures.

n. All alarm circuits connected to simulated alarm contacts to verify operation.

o. All interlock and shutdown circuits checked for operability and proper function by means of simulated contact.

p. All input/output devices and components shall be tested to verify operability and basic calibration.

q. Simulate operation of electronic control and receiving instruments and circuits.

r. Test demonstrating that all specified equipment functional capabilities are working properly.

s. Verify that communication between units is working properly.

t. Any other test required to place the panel in an operating state.

u. Compliance with specifications, standards, and codes.

2. The ENGINEER reserves the right to inspect the work-in-progress at any time during the construction or testing of the panels. CONTRACTOR shall notify ENGINEER when:

   a. Panels are furnished with components and wiring is 25% complete.

   b. Panels are complete and CONTRACTOR tested.

3. The ENGINEER shall have the right to request any additional tests that are deemed necessary to prove the operation of the panel(s) or adherence to the specification, standards, or codes.

4. Witnessing by the ENGINEER of any tests and inspections at the CONTRACTOR's premises (or elsewhere) shall not imply acceptance of responsibility for any faults or failings subsequently found.

5. All problems or discrepancies must be corrected and required retesting completed before final approval for shipment is given by the ENGINEER.

6. It shall be the responsibility of the CONTRACTOR to furnish necessary testing devices and sufficient manpower to perform the tests required by the ENGINEER.

7. Field Testing: Each control panel shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

C. Factory Acceptance Test

1. In the case of PLC and network equipment enclosures, testing at the CONTRACTOR's facility will be required.

2. The CONTRACTOR shall be required to write test plans, if required, and perform the testing. If required, CONTRACTOR shall also perform and document testing prescribed by ENGINEER and to document testing on ENGINEER-provided forms. Testing to be witnessed by the ENGINEER.

3. Copies of all test plans and results, certificates, etc. shall be provided to the ENGINEER.

It shall be the responsibility of the CONTRACTOR to furnish all necessary testing devices which must have a current, valid certificate of calibration. Calibration records must be produced to the ENGINEER on request.

- END OF SECTION -

SECTION 43 25 05 - SUBMERSIBLE SUMP PUMPS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide submersible sump pumps and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 46 01 00 – Equipment General Provisions, apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump that will best satisfy the indicated requirements.

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings

1. Submit pump name, identification number, and specification Section number.

2. Performance Information

a. Submit performance data curves showing head, capacity, horsepower demand, NPSHr3 required, and pump efficiency over the entire operating range of the pumps.

b. Require the equipment manufacturer to indicate the head, capacity, required horsepower, pump efficiency, and NPSHr corresponding to each flow condition indicated in the respective performance requirement paragraph of each individual pump specification section. Indicate on the pump curve the Allowable Operating Region (AOR), Preferred Operation Region (POR), and minimum submergence required at maximum flow for vertical and submersible pumps.

3. Operating Range

a. Require the manufacturer to indicate the limits on the performance curves recommended for stable operation without surge, cavitation, or excessive vibration.

4. Submit assembly and installation drawings, including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.

5. Submit data, in accordance with the requirements of Section 26 05 10 – Electric Motors, for the electric motor proposed for each pump.

6. Submit a complete electrical schematic diagram.

C. Technical Manual

1. Submit a Technical Manual containing the required information indicated in Section 01 33 00 – Contractor Submittals and each specific pump Section.

D. Spare Parts List

1. Submit a spare parts list containing the required information indicated in Section 01 33 00 – Contractor Submittals and each specific pump Section.

E. Certifications

1. Submit the manufacturer's certification of proper installation.

2. Submit the CONTRACTOR's certification of satisfactory field testing.

F.

PART 2 -- PRODUCTS

2.1 GENERAL DESCRIPTION

A. Identification:

SP-001

B. Operating Conditions: The WORK of this Section shall be suitable for long term operation under the following conditions:

Duty	Intermittent
Drive	Constant speed
Ambient environment	Bottom of Valve Vault
Ambient temperature, degrees F	40 to 100
Ambient relative humidity, percent	0 to 100
Fluid service	Process Drainage & Infiltration
Fluid temperature, degrees F	40 to 60
Fluid pH range	6 to 8
Fluid specific gravity	1
Fluid viscosity (absolute), centipoises at 60 deg. F	0.9946
Project site elevation, ft. a.s.l	579
Minimum available NPSH, ft absolute	27

Maximum size of spheres to pass, in. dia	1/2”

C. Performance Requirements: The WORK of this Section shall meet the performance requirements as indicated below:

Maximum shutoff head, ft	38
Design flow capacity, gpm	20
Design flow pump head, TDH ft	31
Maximum flow capacity at maximum speed, gpm	50
Maximum flow pump head, TDH ft	16
Maximum flow NPSH required, ft absolute	10
Minimum flow capacity at maximum speed, gpm	10
Minimum flow pump head, TDH, at maximum speed, ft	34
Maximum pump speed, rpm	3450
Minimum motor size, hp	0.4

D. Pump Dimensions:

Sump dimensions, in	42X42
Sump depth, in	40
Sump top	FBR grating with frame open
Pump discharge size, inches	1.5
Discharge NPT rating, psi	25

2.2 PUMP REQUIREMENTS

A. Construction: Construction of submersible sump pumps shall conform to the following requirements:

Pump casing	Cast iron
Impeller	Semi-open, non-clog cast iron or engineered thermoplastic

Bearings	Permanently lubricated ball and sleeve type
Shaft	Stainless steel, series 400 or AISI1215 steel
Seal	Mechanical seal, carbon and ceramic
Mounting Method	Free standing with stainless steel chain and hook
Pump Connection	1.5 NPT

B. Drive: Enclosed, submerged, electric 3450 rpm motor, suitable for 115 volt, single phase, 60 Hz ac power supply, in accordance with Section 260510 - Electric Motors.

C. Coating: Pumps shall be coated in accordance with Section 09 96 00 – Protective Coatings.

2.3 PUMP CONTROLS

A. Pumps shall be equipped with integral float switches for controlling pump start and stop. A separate high level float switch for the sump shall be furnished as part of, and as specified under, Division 40. Each pump shall be supplied with a vendor-supplied control panel (VCP) and shall house all required controls, circuit breakers, motor starters, and contacts. The VCP shall have a HAND/OFF/AUTO hand switch to permit local operation of each pump, and indicator lights for RUN status and FAIL status. The VCP shall have dry contacts to provide remote monitoring via OWNER's PLC of all status signals as shown on the Contract Documents, which shall include at a minimum FAIL status. The VCP shall satisfy the requirements of Section 26 05 15 – Industrial Control Panels, as applicable to non-hazardous areas.

2.4 MANUFACTURERS, OR APPROVED EQUAL

A. **Zoeller Pump Company**

B. **Pentair (Aurora Pumps)**

C. **Xylem (Flygt) Corporation**

D. **Goulds Pumps Inc.**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General

1. Install pumping equipment in accordance with the manufacturer's written recommendations.

B. Alignment

1. Field-test the equipment in order to verify proper alignment and freedom from binding, scraping, shaft run out, or other defects.

2. Ensure that the equipment is secure in position and neat in appearance.

3.2 PROTECTIVE COATING

A. Coat materials and equipment in accordance with the requirements of Section 09 96 00 – Protective Coating.

3.3 FIELD TESTS

A. Field-test each pump system after installation simulating all of the operational scenarios as specified in order to demonstrate:

1. satisfactory operation without excessive noise and vibration;

2. Meet indicated head, flow, and efficiency at the design point.

B. Conduct the following field testing:

1. Startup, check, and operate the pump system over its entire speed range.

2. If the pump is driven by constant speed, test the pump and motor at the maximum RPM.

C. If the pumping system fails to meet the indicated requirements, modify or replace the pump and re-test as indicated above until it satisfies the indicated requirements.

D. Certification

1. After each pumping system has satisfied the requirements, certify in writing that it has been satisfactorily tested and that final adjustments have been performed.

2. Certification shall include the date of the field tests, a listing of persons present during the tests, and the test data.

E. The CONTRACTOR shall be responsible for costs of field tests, including related services of the manufacturer's representative, except for power and water, which the OWNER will bear.

F. If available, the OWNER'S operating personnel will provide assistance in field testing.

END OF SECTION

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SECTION 43 30 00 - VALVES, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide valves, actuators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 46 01 00 – Equipment General Provisions, apply to the WORK of this Section.

C. The provisions of this Section shall apply to all valves and valve actuators except where otherwise indicated.

D. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls, as indicated.

E. Support

1. Where a valve is to be supported by means other than the piping to which it is attached, obtain from the valve manufacturer a design for its support and foundation that satisfies the criteria in Section 46 01 00 – Equipment General Provisions.

2. Submit the support design, including drawings and calculations sealed by an engineer, with the Shop Drawings.

F. Unit Responsibility

1. The CONTRACTOR shall assign a single manufacturer to be responsible for the supply, coordination of design, assembly, testing, and furnishing of each valve; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each valve Section.

G. Single Manufacturer

1. Where 2 or more valves of the same type and size are required, the valves shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

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

B. Furnish the following information on Shop Drawings:

1. valve name, size, Cv factor, pressure rating, identification number (if any), and specification section number;

2. complete information on the valve actuator, hydraulic power units (HPU), pneumatic air supply system including size, manufacturer, model number, limit switches, and mounting;

3. cavitation limits for control valves;

4. assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, hand wheels, position indicators, limit switches, integral control systems, needle valves, and control systems;

5. data in accordance with Section 26 05 10 – Electric Motors, for electric motor-actuated valves;

6. complete wiring diagrams and control system schematics; and,

7. A valve-labeling schedule, listing the valves to be furnished with stainless steel tags, indicating in each case the valve location and the proposed wording for the label.

C. Furnish a technical manual containing the required information for each valve, as indicated.

D. Furnish a spare parts list, containing the required information for each valve assembly, as indicated.

E. Factory Test Data

1. Where indicated, submit signed, dated, and certified factory test data for each valve requiring certification, before shipping the valve.

2. Furnish a certification of quality and test results for factory-applied coatings.

F. Field Test Data

1. Submit signed, dated, and certified field test data for each valve.

PART 2 -- PRODUCTS

2.1 PRODUCTS

A. General

1. Provide valves and gates of new and current manufacture.

2. Provide valves 6-inch and larger with actuators with position indicators.

3. Unless otherwise indicated, provide valve actuators in accordance with Section 43 30 12 – Valve and Gate Actuators.

B. Protective Coating

1. Coat the exterior surfaces of valves and the wet interior surfaces of ferrous valves of sizes 2-inch and larger in accordance with the requirements of Section 09 96 00 – Protective Coating.

2. The valve manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with the indicated requirements.

3. Do not coat the machined flange faces of valves except where such flanges are not adjoining a mating flange as shown in the Contract Documents. Apply rust inhibitor coating on machined surfaces of the flange prior to shipment.

C. Valve Labeling

1. Except when such requirement is waived by the ENGINEER in writing, provide a label on shut-off valves and control valves except for hose bibbs and chlorine cylinder valves.

2. Furnish a label composed of 1/16-inch plastic or stainless steel, a minimum of 2 inches by 4 inches in size, as indicated in Section 40 05 02 – Piping Identification Systems, and permanently attached to the valve or on the wall adjacent to the valve as directed by the ENGINEER.

D. Valve Testing

1. As a minimum, unless otherwise indicated or recommended by the reference standards, test valves 3 inches in diameter and smaller in accordance with the manufacturer's standard procedure.

2. Factory-test valves 4 inches in diameter and larger as follows:

a. Hydrostatic Testing

1) Subject valve bodies to an internal hydrostatic pressure equivalent to twice the water-rated pressure of the valve.

2) Metallic valves rating pressures shall be based at 100 degrees F.

3) Plastic valves rating pressures shall be based at 73 degrees F, or at a higher temperature according to material type.

4) During the hydrostatic test, there shall be no visible leakage through the valve body, end joints, or shaft seals, nor shall parts of the valve be permanently deformed.

5) Allow test duration of at least 10 minutes, in order to allow visual examination for leakage.

b. Seat Testing

1) Test the valves for leaks in the closed position, with the pressure differential across the seat equal to the water rated pressure of the valve.

2) Provide test duration of at least 10 minutes, in order to allow visual examination for leakage.

3) The leakage rate shall be the more stringent of the following:

a) As recommended by the reference standard for that type of valve; or

b) Leakage past the closed valve not to exceed one fluid ounce per hour per inch diameter for metal seated valves, and drop-tight for resilient seated valves.

c. Performance Testing

1) Shop-operate the valves from the fully-closed to the fully-open position, and reverse under no-flow conditions in order to demonstrate that the valve assembly operates properly.

E. Certification

1. Prior to shipment of valves with sizes larger than 12-inches in diameter, submit certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, or ASTM.

F. Valve Markings

1. Permanently mark valve bodies in accordance with MSS SP25 - Standard Marking Systems for Valves, Fittings, Flanges, and Unions.

2.2 MATERIALS

A. General

1. Provide materials suitable for the intended application.

2. Provide materials in contact with potable water listed as compliant with NSF Standard 61.

3. Ensure that materials not indicated are of high-grade standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended.

4. Unless otherwise indicated, provide valve and actuator bodies conforming to the following requirements:

a. Cast Iron: Close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings

b. Ductile Iron: ASTM A 536 - Ductile Iron Castings, or to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures

c. Steel: ASTM A 216 - Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, or to ASTM A 515 - Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

d. Bronze: ASTM B 62 - Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Copper Alloy Sand Castings for General Applications. Bronze materials in contact with potable water service shall be free of lead content meeting the Lead Reduction Act.

e. Stainless Steel: Stainless steel valve and operator bodies and trim shall conform to ASTM A 351 - Steel Castings, Austenitic, for High-Temperature Service, Grade CF8M, or shall be Type 316 stainless steel

f. PVC: Polyvinyl chloride materials for valve body, flanges, and cover shall conform to Cell Classification 12454

g. CPVC: Chlorinated Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 23447

h. NSF Standard 61: Materials shall be listed for use in contact with potable water.

2.3 VALVE CONSTRUCTION

A. Bodies

1. Provide valve bodies that are cast, molded (in the case of plastic valves), forged, or welded, of the materials indicated, and with smooth interior passages.

2. Provide wall thicknesses uniform and in agreement with the applicable standards for each type of valve, without casting defects, pinholes, and other defects that could weaken the body.

3. Perform welds on welded bodies by certified welders and ground welds smooth.

4. Provide valve ends as indicated, and rated for the maximum temperature and pressure to which the valve will be subjected.

B. Valve End Connections

1. Unless otherwise indicated, valves 2-1/2 inches in diameter and smaller may be provided with threaded end connections.

2. Provide valves 3 inches in diameter and larger with flat faced flanged end connections.

3. Flanges, bolts and gaskets shall be as specified in Section 40 05 00 - Piping, General.

C. Bonnets

1. Connect valve bonnets to the body by clamping, screwing, or flanging.

2. Provide bonnets of the same material, temperature, and pressure rating as the body.

3. Make provisions for the stem seal with the necessary glands, packing nuts, and yokes.

D. Stems

1. Provide valve stems of the materials indicated, or, if not indicated, of the best commercially-available material for the specific service, with adjustable stem packing, O-rings, chevron V-type packing, or other suitable seal. Bronze materials in contact with potable water shall be NSF 61 approved and free of lead. Elastomeric materials shall be compatible with fluid service.

E. Stem Guides

1. Provide stem guides spaced with an L/R ratio not to exceed 200:1. Submit calculations for L/R ratios and guide spacing to the ENGINEER for review.

2. Stem guides shall have slotted holes and shall be adjustable in two directions.

3. Construct submerged stem guides from Type 304 stainless steel.

F. Internal Parts

1. Provide internal parts and valve trim as indicated for each individual valve.

2. Where not indicated, construct valve trim from Type 316 stainless steel or other material best-suited for the intended service.

G. Nuts and Bolts

1. Unless otherwise indicated, provide nuts and bolts on valve flanges and supports in accordance with the requirements of Section 05 50 00 – Miscellaneous Metalwork and Section 40 05 00 – Piping, General.

2.4 Extension Shaft Stem

A. Valves mounted in dry areas with gearbox attached to the valve and with remote actuator shall be supplied with an extension shaft stem with universal joint attached to the gear and actuator. All components shall be sized to operate under the maximum service conditions for the valve. Unless otherwise indicated, shaft stem and universal joints shall be made of carbon steel with epoxy coating suitable for the fluid service. Each valve, shaft stem, floor stand and actuator shall be pre-assembled and "matched marked" in the manufacturer's shop to ensure proper fit when assembled in field.

2.5 VALVE ACTUATORS

A. Valve actuators shall be as indicated and as specified in Section 43 30 12 – Valve and Gate Actuators

2.6 VALVE ACCESSORIES

A. Provide valves complete with the accessories required to provide a functional system.

2.7 SPARE PARTS

A. Furnish the required spare parts, suitably packaged and labeled with the valve name, location, and identification number.

B. Furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve.

C. Spare parts are intended for use by the OWNER, after expiration of the correction of defects period.

2.8 MANUFACTURERS

A. Valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the indicated valves.

PART 3 -- EXECUTION

3.1 VALVE INSTALLATION AND TRIAL OPERATION

A. General

1. Install valves, actuating units, stem extensions, valve boxes, and accessories in accordance with the manufacturer's written instructions and as indicated.

2. Adequately brace gates in order to prevent warpage and bending under the intended use.

3. Firmly support valves in order to avoid undue stresses on the pipe.

B. Access

1. Install valves in a manner to provide easy access for actuation, removal, and maintenance, and to avoid interference between valve actuators and structural members, handrails, and other equipment.

C. Valve Accessories

1. Where combinations of valves, sensors, switches, and controls are indicated, properly assemble and install such items such that systems are compatible and operating properly.

2. Clearly note the relationship between interrelated items on Shop Drawing submittals.

D. Trial Operation

1. After installation, schedule trial operation witnessed by the ENGINEER and the OWNER representative.

2. All valves shall be cleaned thoroughly of all foreign materials and final adjustments made. The valves shall then be operated through one complete cycle from a fully closed position to a fully open position and back to a fully closed position to verify that the assembly is functional.

3. For control valves that operate in multiple operating scenarios, the CONTRACTOR shall simulate all operational scenarios including the hydraulic power units, pilot control system or pneumatic air supply system to demonstrate compliance to the specifications.

4. A field leakage test meeting the maximum allowable specified requirement shall be conducted.

5. Test certificate shall be signed by the valve manufacturer and the CONTRACTOR and shall be submitted to the ENGINEER.

END OF SECTION

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SECTION 43 30 12 - VALVE AND GATE ACTUATORS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide valve and gate actuators and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section apply to valves and gates except where otherwise indicated in the Contract Documents.

C. Unit Responsibility

1. Make the valve or gate manufacturer responsible for the coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the CONTRACTOR shall be responsible to the OWNER for compliance of the valves, gates, and actuators with the Contract Documents.

D. Where 2 or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals and Section 43 30 00 – Valves, General.

B. Submit Shop Drawing information for actuators with the valve and gate submittals as a complete package.

C. Submit calculations showing dynamic seating and unseating torques versus the output torque of the actuator.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, provide shut-off and throttling valves and externally actuated valves and gates with manual or power actuators.

B. Provide actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, hand wheels, levers, chains, and extensions, as applicable.

C. Provide actuators with torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering.

D. Actuator torque ratings for butterfly valves shall be determined in accordance with AWWA C504 - Rubber-Seated Butterfly Valves.

E. Identify wires of motor-driven actuators by unique numbers.

F. Manufacturers

1. Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer.

2. Where actuators are furnished by different manufacturers, coordinate the selection to result in the fewest number of manufacturers possible.

G. Materials

1. Provide actuators of current models, of the best commercial quality materials, and liberally sized for the required torque.

2. Provide materials suitable for the environment in which the valve or gate is to be installed.

H. Actuator Mounting and Position Indicators

1. Securely mount actuators by means of brackets or hardware specially designed and sized for this purpose and of ample strength.

2. Cast the word "OPEN" on each valve or actuator, with an arrow indicating the direction to open in the counter-clockwise direction.

3. Equip gear and power actuators with position indicators.

4. Where possible, locate manual actuators between 48 and 60 inches above the floor or the permanent working platform.

I. Standards

1. Unless otherwise indicated and where applicable, provide actuators in accordance with AWWA C 542 - Electric Motor Actuators for Valves and Slide Gates.

J. Provide fasteners in accordance with the requirements of Section 05 50 00 – Miscellaneous Metalwork.

K. Provide coatings in accordance with the requirements of Section 09 96 00 – Protective Coating.

2.2 MANUAL ACTUATORS

A. General

1. Unless otherwise indicated, provide valves and gates with manual actuators.

2. Provide valves in sizes up to and including 4 inches with direct-acting lever or hand wheel actuators of the manufacturer's best standard design.

3. Provide valves and gates larger than 4-inch with gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the hand wheel.

4. Provide buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psig, valves 30 inches in diameter and larger, and where indicated, with worm gear actuators, hermetically-sealed water-tight and grease-packed.

5. Valves 6-inch to 24-inch diameter may be provided with traveling-nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. Floor Boxes

1. Provide hot-dipped galvanized cast iron or steel floor boxes and covers to fit the slab thickness, for operating nuts in or below concrete slabs.

2. For operating nuts in the concrete slab, provide a bronze-bushed cover.

C. Manual Worm Gear Actuator

1. Provide an actuator consisting of a single- or double-reduction gear unit contained in a weatherproof cast iron or steel body with cover, and a minimum 12-inch diameter handwheel.

2. Provide the actuator to be capable of a 90-degree rotation, and equip the actuator with travel stops capable of limiting the valve opening and closing.

3. Provide the actuator with spur or helical gears and worm gearing.

4. Provide a self-locking gear ratio in order to prevent "back-driving."

5. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.

6. Construct the worm gear shaft and the hand wheel shaft from 17-4 PH or similar stainless steel.

7. Accurately cut gearing with hobbing machines.

8. Use ball or roller bearings throughout.

9. Provide the output shaft end with a spline in order to allow adjustable alignment.

10. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator.

11. Design gearing for a 100 percent overload.

12. The entire gear assembly shall be sealed weatherproof.

D. Design and rate buried gear actuators for buried service, provide with a stainless steel input shaft, and double-seal on shaft and top cap.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Field Adjustments

1. The adjustment of actuator controls and limit switches in the field for the required function shall be performed by field representatives of the manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators.

3.2 INSTALLATION

A. Install valve and gate actuators and accessories in accordance with the requirements of Section 43 30 00 – Valves, General.

B. Locate the actuators to be readily accessible for operation and maintenance without obstructing walkways.

C. Do not mount actuators where shock or vibrations will impair their operation, and do not attach the support systems to handrails, process piping, or mechanical equipment.

END OF SECTION

SECTION 43 30 14 - BUTTERFLY VALVES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 46 01 00 – Equipment General Provisions apply to this Section.

C. The requirements of Section 43 30 00 - Valves, General apply to this Section.

D. The requirements of Section 09 96 00 – Protective Coating apply to this Section.

E. The requirements of Section 43 30 12 - Valve Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 30 00 – Valves, General.

B. Shop Drawings

1. Complete Shop Drawings of butterfly valves and actuators.

2. Drawings showing valve port diameter complete with dimensions, part numbers, and materials of construction.

3. Certified statement of proof-of-design tests from the valve manufacturer. Valve manufacturer shall state that the valves proposed for this project will be manufactured with identical basic type of seat design and materials of construction to the prototype evaluated under the proof of design testing.

4. Manufacturer's certification that the valve complies with applicable provisions of AWWA C504 – Rubber-Seated Butterfly Valves.

1.3 QUALITY ASSURANCE

A. Valves shall be subjected to performance, leakage, and hydrostatic tests in accordance with procedures and acceptance criteria established by AWWA C504.

PART 2 -- PRODUCTS

2.1 RUBBER SEATED BUTTERFLY VALVES 25 TO 150 PSI (AWWA)

A. General: Butterfly valves for steady-state water working pressures and steady-state differential pressure up to 150 psi and for fresh water service having a pH range from 6 to 10 and temperature range from 33 to 125 degrees F shall conform to AWWA C504 and be as indicated. Valves subjected to steady state working pressures and steady state differential pressures from 25 to 150 psi in sizes 3-inches through 24-inches shall be rated for Class 150B with actuator sized for Class 150B. Valves 30 inches through 72-inches shall be of the class indicated. Valves larger than 72-inches shall be of the class indicated, designed in accordance with the intent of AWWA C504. If the operating

conditions such as flow, velocity, and differential pressures are not indicated, the valve body and shaft shall be sized for the pressure class rating of the valve.

B. Valves shall be of the body type, pressure class, end joint, and actuator indicated.

C. Construction: Unless otherwise indicated, materials of construction shall be in accordance with AWWA C504, suitable for the service. Seats shall be positively clamped or bonded into the disc or body of the valve, but cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. Seat material shall be guaranteed to last for at least 75 percent of the number of cycles in the AWWA C504 proof-of-design test without premature damage.

Description	Material Standards
Valve bodies	Gray iron, ASTM A 48, Class 40 or Ductile iron, ASTM A 536, grade 65-45-12 or 70-50-05
End flanges	Same material as valve bodies
Valve shafts	Stainless steel ASTM A 240 or A 276, Type 316
Valve discs	Same material as valve bodies.
Rubber seats	New natural or synthetic rubber
Seat mating surfaces	Stainless steel, ASTM A 240 or A 276, Type 316
Clamps and retaining rings	Type 316 retaining rings and cap screws.
Valve bearings	Self lubricating materials per AWWA C504
Shaft seals	Resilient non-metallic materials suitable for service
Painting and coating	Refer to Section 09 96 00 – Protective Coating

D. Manual Actuators: Unless otherwise indicated, manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30-inches in diameter and larger.

E. Worm Gear Actuators: Valves 30-inches and larger, as well as submerged and buried valves, shall be equipped with worm-gear actuators, lubricated and sealed to prevent entry of dirt or water into the housing.

F. Manufacturers, or Equal

1. **Val-Matic Valve & Manufacturing Corporation**

2. **DeZURIK Water Controls, Corporation**

3. **Kennedy Valve**

4. **M & H Valve Company**

5. **Mueller Company**

6. **Henry Pratt Company**

PART 3 --

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. Installation shall be in accordance with Section 43 30 00 – Valves, General.

B. High strength bolts shall be used for VF-101 in accordance with Section 05 50 00 – Miscellaneous Metalwork.

VALVE SCHEDULE

TAG NO.	LOCATION	DIAMETER	SERVICE	TYPE	SPECIFICATION	STYLE	ACTUATOR TYPE	VALVE CLASS	DWG. NO.	P&ID NO.
A8	36” Bypass	36”	RW	Butterfly	43 30 14	MJ (Field Verify)	Buried Service with Nut	150 psi	C-006	I-007
A15	Shorewell #1	48"	RW	Butterfly	43 30 14	Flanged	Pedestal Mounted Manual Handwheel	150 psi	C-007	I-007
VF-101	Valve Vault	48"	RW	Butterfly	43 30 14	Flanged	Pedestal Mounted Manual Handwheel	150 psi	M-005	I-007

END OF SECTION

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SECTION 43 30 16 - CHECK VALVES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide check valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 30 00 - Valves, General apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 30 00 – Valves, General.

PART 2 -- PRODUCTS

2.1 SWING CHECK VALVES (2-1/2 INCHES AND SMALLER)

A. General: Swing check valves for steam, water, oil, or gas in sizes 2-1/2 inches and smaller shall be suitable for a steam pressure of 150 psi and a cold water pressure of 300 psi. Units shall have screwed ends unless otherwise indicated, and screwed caps.

B. Body: The valve body and cap shall be of bronze conforming to ASTM B 763 - Copper Alloy Sand Castings for Valve Application, or ASTM B 584 with threaded ends conforming to ASME B1.20.1 - Pipe Threads, General Purpose (inch).

C. Disc: Valves for steam service shall have bronze or brass discs conforming to ASTM B 16 - Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines, and for cold water, oil, and gas service replaceable composition discs.

D. Hinge Pin: The hinge pins shall be of bronze or stainless steel.

E. Manufacturers, or Equal

1. **Crane Company**

2. **Milwaukee Valve Company**

3. **Stockham Valves and Fittings**

4. **Wm. Powell Company**

PART 3 -- EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with provisions of Section 43 30 00 - Valves, General.

END OF SECTION

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SECTION 43 30 18 - BALL VALVES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide ball valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 30 00 - Valves, General apply to this Section.

C. The requirements of Section 43 30 12 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 30 00 - Valves, General.

PART 2 -- PRODUCTS

2.1 METAL BALL VALVES (4-INCHES AND SMALLER)

A. General: Unless otherwise indicated, general purpose metal ball valves in sizes up to 4-inches shall have actuators in accordance with Section 43 30 12 - Valve and Gate Actuators.

B. Body: Ball valves up to and including 1-1/2 inches in size shall have bronze or carbon steel 2 or 3 piece bodies with screwed ends for a pressure rating of not less than 600 psi WOG. Valves 2-inches to 4-inches in size shall have bronze or carbon steel 2 or 3 piece bodies with flanged ends for a pressure rating of ANSI 125 psi or 150 psi unless otherwise indicated.

C. Balls: The balls shall be solid chrome-plated brass or bronze, or stainless steel, with standard port (single reduction) or full port openings.

D. Stems: The valve stems shall be of the blow-out proof design, of bronze, stainless steel, or other acceptable construction, with reinforced teflon seal.

E. Seats: The valve seats shall be of teflon or Buna-N, for bi-directional service and easy replacement.

F. Manufacturers, or Equal

1. **Conbraco Industries, Inc. (Apollo)**

2. **ITT Engineered Valves**

3. **Neles-Jamesbury, Inc.**

4. **Watts Regulator**

5. **Worcester Controls**

2.2 PLASTIC BALL VALVES

A. General: Plastic ball valves for corrosive fluids shall be made of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polypropylene (PP), or polyvinylidene fluoride (PVDF), as recommended by the manufacturer for the specific application. Valves shall have manual actuators in accordance with Section 43 30 12 - Valve and Gate Actuators, unless otherwise indicated.

B. Construction: Plastic ball valves shall have union ends or flanged ends to mate with ANSI B 16.5, class 150 flanges for easy removal. The balls shall have full size ports and teflon seats. Body seals, union O-ring seals, and stem seals shall be suitable for the material being conveyed through the valve. External (without entering into the wetted area) seat packing adjustment is preferred. Metal reinforced stems to prevent accidental breakage are preferred. Ball valves for sodium hypochlorite solution service shall be drilled through the ball or body per valve manufacturer recommendation to relieve offgas and equalize pressure across the valve. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F for PVC and CPVC, with decreasing ratings for higher temperatures and other plastics.

C. Manufacturers, or Equal

1. **ASAHI-America**

2. **George Fischer, Inc.**

3. **NIBCO Inc., (Chemtrol)**

4. **Plast-O-Matic Valves, Inc.**

5. **Spears Mfg. Co.**

6. **Watts Regulator**

PART 3 -- EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with Section 43 30 00 – Valves, General. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

END OF SECTION

SECTION 43 52 04 – JIB CRANES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wall mounted jib crane and hoisting equipment, ancillary steel, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS CODES, AND STANDARDS

A. Commercial Standards

AISC	Specifications for the Design, Fabrication, and Erection of Structural Steel for Building
AGMA	American Gear Manufacturer’s Association
ASTM A 36	Carbon Structural Steel
CMAA	A division of Material Handling Industry of America
OSHA 29 CFR 1926.550	Cranes and Derricks

1.2 CONTRACTOR SUBMITTALS

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

B. Shop Drawings shall include weights, wheel loads, dimensions of members, base plates and required clearances.

C. Equipment Anchorage

D. Technical Manuals

1. Include complete operating and maintenance instructions of the hoist and crane systems.

1.3 QUALITY ASSURANCE

A. Inspection and Testing Requirements

1. After installation, the CONTRACTOR shall inspect and test hoists and crane systems in the presence of the manufacturer's service representative, for proper operation and conformance to the indicated requirements.

B. Acceptance Criteria and Tolerances

1. The ENGINEER reserves the right to reject any equipment not conforming to the tolerances, deflections, and lateral stiffness as indicated.

1.4 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall arrange for the hoist or crane manufacturer to furnish the services of a trained, qualified representative for at least one day after the units are installed, for the purpose of inspecting the installation and instructing the OWNER's operating personnel.

1.5 ANCHORAGE DESIGN

A. Equipment anchorage shall be designed in accordance with the requirements of Section 01 33 17 – Structural Design, Support and Anchorage.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Equipment of similar design shall be from a single manufacturer.

B. The capacity of each hoist and trolley shall be permanently marked in a conspicuous manner on the equipment.

C. Hooks shall be of the safety type with a latch.

D. The CONTRACTOR shall verify dimensions and clearances in the field prior to installation and shall be responsible for the proper fitting and operation of the equipment.

2.2 BASIC MATERIALS

A. Materials shall be new and of the best commercial grade.

B. Where materials are not indicated, the CONTRACTOR shall have the manufacturer use the most suitable selection for the given application and environment.

2.3 PLANT FABRICATED ITEMS

A. Fabrication, assembly, and welding shall be performed by factory-trained specialists and certified welders.

2.4 JIB CRANE

A. Jib Cranes shall comply with AISC Steel Construction Manual, OSHA 1910.179, ANSI B30.11, and CMAA 74.

B. Jib Crane shall be wall cantilever style fabricated using ASTM A36 steel sections with finished ends and surfaces. with horizontal boom attached to a vertical mast capable of rotating 180 degrees design for a maximum deflection of L/150.

C. The crane’s structural design is based on live load capacity plus 15 percent for hoist and trolley weight and 25 percent for impact. Crane shall be designed to withstand

1. Crane and hoist dead load.

2. Live load capacity equal to net rated hook load.

3. Inertia forces from crane and load movement.

D. Jib Crane shall have a 10’ span and 1 ton capacity.

E. Bracket fitting shall be bronze bushings with oil-impregnated bronze thrust washers.

F. Manufacturers, or Approved Equal

1. **Gorbel, WC200 series**

2. **Spanco, 300 series**

2.5 HOIST AND TROLLEY

A. Manual hoist and trolley system shall be under-hung type with a minimum 1 ton capacity and minimum lift of 30 feet. Hoist and trolley system shall be compatible with supplied jib crane.

B. Hoist shall be a chain style hoist with grade 80 alloy steel chain with galvanized finish. Hooks shall be alloy steel, heat treated and equipped with spring-return hook latches. Brake system shall be composed of a reinforces double pawl brake with large diameter pawl springs.

C. Trolley shall be manual hand geared type with chain with crown-tread wheels compatible for use on the jib crane beam. Wheel bearings shall be anti-friction, sealed and maintenance-free.

D. Manufacturers, or Approved Equal

1. **R&M Materials Handling, Inc.**

2. **Ingersoll Rand**

2.6 ANCHORAGE

A. Provide cast-in-anchor bolts to concrete wall. Contractor shall coordinate anchor bolt layout and design requirements with Jib Crane base plate configuration. Care shall be taken to install cast-in-anchor bolts clear from concrete wall reinforcement.

2.7 TOOLS AND SPARE PARTS

A. Tools

1. The CONTRACTOR shall furnish one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment.

2. The tools shall be of best quality and furnished in labeled toolboxes of suitable design.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Hoist and crane equipment shall be installed in strict accordance with the manufacturer's printed instructions.

B. Workmanship shall be in accordance with the referenced standards and codes.

C. Care shall be taken that the structural integrity of beams, columns, walls, floors, and roofs will be maintained at all times.

3.2 FIELD TESTING

A. After completion of the WORK, the CONTRACTOR shall test hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify in writing that the equipment meets applicable standards and specifications.

END OF SECTION

SECTION 46 01 00 - EQUIPMENT GENERAL PROVISIONS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide equipment and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to equipment throughout the Contract except where otherwise indicated.

C. All component and support systems of the equipment shall be designed and manufactured to withstand all forces such as internal or external, static, wind, dynamic and seismic loads. Submit a copy of that analysis for review by the ENGINEER.

D. Equipment Arrangement: Unless specifically indicated otherwise, the arrangement of equipment indicated is based upon information available from manufacturers at the time of design and is not intended to show exact dimensions particular to a specific manufacturer. Some aspects of the Drawings are diagrammatic and some features of the illustrated equipment arrangement may require revision by the CONTRACTOR to meet the actual equipment requirements proposed by the CONTRACTOR. Structural supports, foundations, piping and valve connections, and electrical and instrumentation connections indicated may have to be altered by the CONTRACTOR to accommodate the equipment provided. No additional payment will be made to the CONTRACTOR for such revisions and alterations. Substantiating calculations and drawings shall be submitted prior to beginning the fabrication of equipment.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Equipment shall be in accordance with the following standards, as applicable and as indicated in each equipment specification:

1. American Society for Testing and Materials (ASTM).

2. American National Standards Institute (ANSI).

3. American Society of Mechanical Engineers (ASME).

4. American Water Works Association (AWWA).

5. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).

6. American Welding Society (AWS).

7. National Fire Protection Association (NFPA).

8. Federal Specifications (FS).

9. National Electrical Manufacturers Association (NEMA).

10. Manufacturer's published recommendations and specifications.

11. Occupational Safety and Health Administration (OSHA).

12. Hydraulic Institute (HI)

B. The following standards are referenced in this Section:

ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
ASME B16.5	Pipe Flanges and Flanged Fittings, Steel, Nickel Alloy and other Special Alloys
ASME B46.1	Surface Texture
ANSI S12.6	Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors
ASME B1.20.1	General Purpose Pipe Threads (Inch)
ASME B31.1	Power Piping
ASME B31.3	Process Piping
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm through 3,600 mm)
ASTM A 48	Gray Iron Castings
ASTM A 108	Steel Bars, Carbon, Cold-Finished, Standard Quality

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings: Furnish complete drawings and technical information for equipment, piping, valves, and controls. Where indicated or required by the ENGINEER, Shop Drawings shall include clear, concise calculations showing equipment anchorage forces and the capacities of the anchorage elements proposed by the CONTRACTOR.

C. Spare Parts List: The CONTRACTOR shall obtain from the manufacturer and submit as part of Shop Drawings a list of suggested spare parts for each piece of equipment. CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment.

1.4 QUALITY ASSURANCE

A. Costs: Responsibility shall be the CONTRACTOR'S for performing and paying the costs of inspection, startup, testing, adjustment, and instruction services performed by factory representatives. The OWNER will pay for costs of power and water. If available, the OWNER'S operating personnel will provide assistance in the field testing.

B. Inspection: The CONTRACTOR shall inform the local authorities, such as building and plumbing inspectors, fire marshal, OSHA inspectors, and others, to witness required tests for piping, plumbing, fire protection systems, pressure vessels, safety systems, cranes, and related items to obtain required permits and certificates, and shall pay inspection fees.

C. Quality and Tolerances: Tolerances and clearances shall be as shown on the Shop Drawings and shall be closely adhered to.

1. Machine WORK shall be of high-grade workmanship and finish, with due consideration to the special nature or function of the parts. Members without machined or milled ends and which are to be framed to other steel parts of the structure may have a variation in the detailed length of not greater than 1/16-inch for members 30-feet or less in length, and not greater than 1/8-inch for members over 30-feet in length.

2. Castings shall be homogeneous and free from non-metallic inclusions and defects. Surfaces of castings which are not machined shall be cleaned to remove foundry irregularities. Casting defects not exceeding 12.5 percent of the total thickness and where defects will not affect the strength and serviceability of the casting may be repaired by approved welding procedures. The ENGINEER shall be notified of larger defects. No repair welding of such defects shall be carried out without the ENGINEER'S written approval. If the removal of metal for repair reduces the stress resisting cross-section of the casting by more than 25 percent or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then the casting may be rejected. Costs of casting new material shall be the CONTRACTOR'S responsibility as part of the WORK.

3. Materials shall meet the physical and mechanical properties in accordance with the reference standards.

D. Machine Finish: The type of finish shall be the most suitable for the application as recommended by the equipment manufacturer in micro-inches in accordance with ANSI B46.1. In the absence of manufacturer's recommendations, the following surface finishes shall be used:

1. Surface roughness not greater than 63 micro-inches shall be required for surfaces in sliding contact.

2. Surface roughness not greater than 250 micro-inches shall be required for surfaces in contact where a tight joint is not required.

3. Rough finish not greater than 500 micro-inches shall be required for other machined surfaces.

4. Contact surfaces of shafts and stems which pass through stuffing boxes and contact surfaces of bearings shall be finished to not greater than 32 micro-inches.

E. Manufacturer's Experience: Unless otherwise noted, equipment manufacturer shall have a record of proven experience of at least 5 years of successful, troublefree operation in similar applications and size equal or larger than the equipment in this Contract. Where indicated in each individual equipment specifications, the CONTRACTOR shall submit this experience record to the ENGINEER for approval.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Noise Level: When the equipment is in operation, no single piece of equipment shall exceed the OSHA noise level requirement of 105 dBA for one hour exposure per day.

B. High Noise Level Location: The CONTRACTOR shall provide one personal hearing protection station at each location defined as follows:

1. Indoor Location

a. Any single equipment item or any group of equipment items located within a single room not normally occupied, that produces noise exceeding OSHA noise level requirements for a 2 hour exposure.

C. Personal Hearing Protection: The CONTRACTOR shall furnish 3 pairs of high attenuation hearing protectors in the original unopened packaging. The ear protectors shall be capable of meeting the requirements of ANSI S12.6 and shall produce a noise level reduction of 25 dBA at a frequency of 500 Hz. The hearing protectors shall have fluid filled ear cushions and an adjustable, padded headband. The protectors shall be stored in a weatherproof, labeled, steel cabinet, provided at an approved location near the noise producing equipment.

D. For service factors of electric motors, see Section 26 05 10 - Electric Motors.

E. Where load classifications are not indicated, the equipment manufacturer’s recommendations for service factors shall be utilized.

F. Welding: Unless otherwise indicated, welding shall conform to the following:

1. Latest revision of AWWA D100.

2. Latest revision of AWWA C206.

3. Composite fabricated steel assemblies that are to be erected or installed inside a hydraulic structure, including any fixed or movable structural components of mechanical equipment, shall have continuous seal welds to prevent corrosion of hard-to-coat metallic surfaces.

4. Welding shall be by the metal-arc method or gas-shielded arc method as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards.

5. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the AWS code. Upon completion of welding, weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance with uniform weld contours and dimensions. Sharp corners of material that are to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.

G. Protective Coating: Equipment shall be painted or coated in accordance with Section 09 96 00 - Protective Coating, unless otherwise indicated. Non-ferrous metal and corrosion-resisting steel surfaces shall be coated with grease or lubricating oil. Coated surfaces shall be protected from abrasion or other damage during handling, testing, storing, assembly, and shipping.

H. Potable Water Contact: Materials immersed in or exposed to potable water shall be made of materials or coated compliant with NSF Standard 61. Bronze alloy materials in contact with potable water shall be constructed of zero-lead materials or materials whose lead content do not exceed the weighted average criteria as required by the Lead Reduction Act. Equipment manufacturer shall submit to the ENGINEER a certification of compliance with the requirement of NSF Standard 61 and the Lead Reduction Act.

I. Protection of Equipment: Machined and coated surfaces shall be protected by rust inhibitor material prior to shipment. Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry. Equipment with anti-friction bearings or sleeve bearings shall be protected from being damaged due to jarring motion during shipment. Pumps, motors, drives, electrical equipment, and other equipment having anti-friction or sleeve bearings shall be stored in weathertight storage facilities prior to installation. For extended storage periods, plastic equipment wrappers should be avoided to prevent accumulation of condensate in gears and bearings. In addition, motor space heaters shall be energized and shafts shall be rotated per manufacturer’s recommendation. Equipment delivered to the Site with rust or corroded parts shall be rejected. If equipment develops defects during storage, it shall be disassembled, cleaned, recoated, or otherwise corrected to restore it to original condition.

J. Identification of Equipment Items

1. At the time of shipping, each item of equipment shall have a legible identifying mark corresponding to the equipment number in the Contract Documents for the particular item.

2. After installation, each item of equipment shall be given permanent identification.

    a. Pumps, compressors, and blowers of 150 horsepower or less shall receive acrylic plastic nametags.

    b. Pumps, compressors, and blowers larger than 150 horsepower shall receive stainless steel plate nametags.

K. Vibration Isolators: Air compressors, blowers, engines, inline fans shall be provided with restrained spring-type vibration isolators or pads per manufacturer's written recommendations. Vibration isolations shall be provided with seismic restraint.

L. Equipment Maximum Allowable Vibration Level: Unless otherwise indicated, maximum allowable vibration level shall be in accordance with the acceptance criteria recommended by the reference Standard for that particular type of equipment

M. Shop Fabrication: Shop fabrication shall be performed in accordance with the Contract Documents and the Shop Drawings.

N. Controls: Equipment and system controls shall be in accordance with Division 40 - Instrumentation.

2.2 EQUIPMENT SUPPORTS AND FOUNDATIONS

A. Equipment Supports: Equipment components and supports, anchors, and seismic restrainers shall be adequately designed for static, dynamic, wind, and seismic loads. The design horizontal seismic force shall be the greatest of the following design criteria:

1. Design Criteria noted in Section 01 33 17 – Structural Design, Support and Anchorage.

B. Submit design calculations for equipment supports, anchors, and seismic restrainers signed and sealed by an engineer registered in the State wherein the project is to be built. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, and normal operation plus wind loadings in accordance with Section 01 33 17 – Structural Design, Support and Anchorage.

1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

2. Seismic requirements: Freestanding and wall-hung equipment shall be anchored in place by methods that satisfy Section 01 33 17 – SeismStructural Design, Support and Anchorage. Calculations shall be performed and signed and stamped for equipment weighing more that 400 pounds. Calculations shall analyze lateral and overturning forces and shall include a factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.

3. Wind requirements: Exterior freestanding equipment shall be anchored in place by methods that satisfy Section 01 33 17 – Structural Design, Support and Anchorage. Calculations shall be performed and signed and stamped, analyzing lateral and overturning forces and shall include a factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.

4. Anchors: Anchor bolts shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork. CONTRACTOR shall determine the size, type, capacity, location, and other placement requirements of anchorage elements. Anchoring methods and leveling criteria in the manufacturer's literature shall be followed. Submit methods and criteria with the Shop Drawings.

5. Equipment Foundations: Unless otherwise indicated, mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on minimum 3.5-inch high concrete bases. Unless otherwise indicated on the Drawings, pumps, blowers, compressors and engine driven equipment shall be provided with a concrete foundation with a total weight equal to at least five times the weight of the equipment. Concrete foundations shall be isolated from the building floor in order to prevent transfer of vibration from the equipment to the building structure. The CONTRACTOR through the equipment manufacturer shall verify the size and weight of equipment foundation to insure compatibility with equipment.

6. Equipment Grout: Mechanical equipment installed on top of concrete foundations or bases shall be provided with non-shrink concrete or epoxy grout as indicated and as specified in Section 03 60 00 - Grouting. Grout shall be applied between the base plate and the concrete foundation or base in accordance with the grout manufacturer's recommendation. Grout shall be free of void space.

2.3 SHAFTING

A. General: Equipment manufacturer shall be responsible for designing and manufacturing shafting to carry all loads applied to the shaft. Shafting shall be continuous between bearings and shall be sized to transmit the power required. Keyways shall be accurately cut in line. Shafting shall not be turned down at the ends to accommodate bearings or sprockets whose bore is less than the diameter of the shaft. Shafts shall rotate in the end bearings and shall be turned and polished, straight, and true.

B. Design Criteria: Shafts shall be designed to carry the steady state and transient loads suitable for unlimited number of load applications.

C. Materials: Shafting materials shall be compatible with the type of service and load transmitted. Environmental elements such as corrosive gases, moisture, and fluids shall be taken into consideration. Materials shall be as indicated unless furnished as part of an equipment assembly.

1. Low carbon cold-rolled steel shafting shall conform to ASTM A 108, Grade 1018.

2. Medium carbon cold-rolled shafting shall conform to ASTM A 108, Grade 1045.

3. Other grades of carbon steel alloys shall be suitable for service and load.

4. Corrosion-resistant shafting shall be stainless steel or Monel, whichever is most suitable for the intended service.

D. Differential Settlement: Where differential settlement between the driver and the driven equipment may occur, a shaft of sufficient length with 2 sets of universal type couplings shall be provided.

2.4 BEARINGS

A. General: Bearings shall conform to the standards of the American Bearing Manufacturers Association, Inc. (ABMA).

B. To assure satisfactory bearing application, fitting practice, mounting, lubrication, sealing, static rating, housing strength, and lubrication shall be considered in bearing selection.

C. Re-lubricatable type bearings shall be equipped with hydraulic grease fitting in an accessible location and shall have sufficient grease capacity in the bearing chamber.

D. Lubricated-for-life bearings shall be factory-lubricated with the manufacturer's recommended grease to insure maximum bearing life and best performance.

E. Anti-Friction Type Bearing Life: Except where otherwise indicated, bearings shall have a minimum L-10 life expectancy of 5 years or 20,000 hours, whichever occurs first. Where so indicated, bearings shall have a minimum rated L-10 life expectancy corresponding to the type of service, as follows:

Type of Service	Design Life, years	L-10 Design Life, hours
	(whichever comes first)	
8-hour shift	10	20,000
16-hour shift	10	40,000
Continuous	10	60,000

F. Bearing housings shall be of cast iron or steel and bearing mounting arrangement shall be as indicated or as recommended in the published standards of the manufacturer. Split-type housings may be used to facilitate installation, inspection, and disassembly.

G. Sleeve Type Bearings: Sleeve-type bearings shall have a cast iron or ductile iron housing and Babbitt or bronze liner. Bearing housing shall be bolted and doweled to the lower casing half. These housings shall be provided with cast iron caps bolted in place and the bearing end caps shall be bored to receive the bearing shells. Sleeve bearings shall be designed on the basis of the maximum allowable load permitted by the bearing manufacturer. If the sleeve bearing is connected to an equipment shaft with a coupling, the coupling transmitted thrust will be assumed to be the maximum motor or equipment thrust. Lubricant, lubrication system, and cooling system shall be as recommended by the bearing manufacturer. In accordance with the Lead Reduction Act, sleeve bearings containing lead material exposed to drinking water shall not be acceptable.

H. Plate Thrust Bearings: Thrust bearings shall be the Kingsbury Type, designed and manufactured to maintain the shaft in the fixed axial position without undue heating or the necessity of adjustment or attention. Bearings shall be oil lubricated to suit the manufacturer's standard method of lubrication for the specific bearing. If bearing cooling is required, manufacturer shall provide heat exchangers, incluging necessary intrumentation and controls, piping, filters, and valves.

2.5 PIPING CONNECTIONS

A. Pipe Hangers, Supports, and Guides: Pipe connections to equipment shall be supported, anchored, and guided to avoid stresses and loads on equipment flanges and equipment. Supports and hangers shall be in accordance with Section 40 05 07 - Pipe Supports.

B. Flanges and Pipe Threads: Flanges on equipment and appurtenances shall conform to ASME B16.1, Class 125, or B16.5, Class 150, unless otherwise indicated. Pipe threads shall be in accordance with ASME B1.20.1 and Section 40 05 00 - Piping, General.

C. Flexible Connectors: Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment and in piping systems in accordance with the requirements of Section 40 05 00 – Piping, General. Flexible connectors shall be harnessed or otherwise anchored to prevent separation of the pipe where required by the installation.

D. Insulating Connections: Insulating bushings, unions, couplings, or flanges, as appropriate, shall be used in accordance with the requirements of the specifications.

2.6 GASKETS AND PACKINGS

A. Gaskets and packings shall be in accordance with the requirements of the specifications. Gaskets and packings in contact with drinking water shall be NSF 61 approved. Elastomeric materials in contact with water with chloramines, or water with ozone residual shall be made of Teflon or Viton-A, or equal.

B. Packing around valve stems and reciprocating shafts shall be of compressible material, compatible with the fluid being used. Chevron-type "V" packing shall be Garlock No. 432, John Crane Everseal, or equal.

2.7 NAMEPLATES

A. Equipment nameplates of stainless steel shall be engraved or stamped and fastened to the equipment in an accessible location with No. 4 or larger oval head stainless steel screws or drive pins. Nameplates shall contain the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the machine performance ratings.

2.8 TOOLS AND SPARE PARTS

A. Tools: The CONTRACTOR shall furnish one complete set of special wrenches and other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality hardened steel forgings with bright finish. Wrench heads shall have work faces dressed to fit nuts. Tools shall be suitable for professional work and manufactured by Snap On, Crescent, Stanley, or equal. The set of tools shall be neatly mounted in a labeled toolbox of suitable design provided with a hinged cover.

B. Spare parts shall be furnished as indicated in the individual equipment sections. Spare parts shall be suitably packaged in a metal box and labeled with equipment numbers by means of stainless steel or solid plastic nametags attached to the box.

2.9 EQUIPMENT LUBRICANTS

A. The CONTRACTOR shall provide lubricants for equipment during shipping, storage, and prior to testing, in accordance with the manufacturer’s recommendations. Lubricants that could come in contact with potable water shall be food grade lubricants. After successful initial testing, final testing, and satisfactory completion startup testing per Section 01 75 00 - Equipment Testing and Plant Startup, the CONTRACTOR shall conduct one complete lubricant change on equipment. In addition, the CONTRACTOR shall be responsible for the proper disposal of used lubricants. The OWNER will then be responsible for subsequent lubricant changes

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Installation Supervision, Inspection, Startup, and Field Adjustment: An authorized, experienced, and competent service representative of the manufacturer shall visit the Site to perform the following:

1. Supervision of the installation of the equipment

2. Inspection, checking, and adjusting the equipment and approving its installation

3. Startup and field testing for proper operation, efficiency, and capacity

4. Performing field adjustments during the test period to ensure that the equipment installation and operation comply with requirements

5. Certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.

6. Unless otherwise indicated, factory representative shall be present at the job site for the following number of days:

a. Half a day per equipment for smaller than 500 horsepower.

b. One day per equipment for 500 horsepower and larger.

B. Owner Staff Training

1. Owner staff training shall be in accordance with Section 01 79 00 – Owner Staff Training.

2. Unless otherwise indicated, a minimum of one day of training shall be provided for each type of equipment.

3.2 INSTALLATION

A. General: Equipment shall be installed in accordance with the manufacturer’s written recommendations.

B. Alignment: Equipment shall be field tested to verify proper alignment.

3.3 PACKAGED EQUIPMENT

A. When any system is furnished as pre-packaged equipment, the CONTRACTOR shall coordinate space and structural requirements, clearances, utility connections, signals, and outputs with Subcontractors to avoid later change orders.

B. If the packaged system has any additional features (as safety interlocks, etc.) other than required by the Contract Documents, the CONTRACTOR shall coordinate such features with the ENGINEER and provide material and labor necessary for a complete installation as required by the manufacturer.

3.4 FIELD ASSEMBLY

A. Studs, cap screws, bolt and nuts used in field assembly shall be coated with Never Seize compound or equal.

3.5 WELDING

A. Welds shall be cleaned of weld-slag, splatter, etc. to provide a smooth surface.

3.6 FIELD TESTS

A. Where indicated by the individual equipment sections, equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or overheating of bearings or motor.

B. The following field testing shall be conducted:

1. Start equipment, check, and operate the equipment over its entire operating range. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable standards.

2. Obtain concurrent readings of motor voltage, amperage, capacity, vibration, and bearing temperatures.

3. Operate equipment indicated in Section 01 75 00 – Equipment Testing and Plant Startup.

C. The ENGINEER shall witness field-testing. The CONTRACTOR shall notify the ENGINEER of the test schedule 3 Days in advance.

D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and retested until it satisfies the requirement.

END OF SECTION

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Appendix A

Onshore Geotechnical Data Report

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April 20, 2020
Local Office

TESTING SERVICE CORPORATION

Local Office:
457 E. Gundersen Drive, Carol Stream, IL 60188-2492
630.653.3920 • Fax 630.653.2726

Corporate Office:
360 S. Main Place, Carol Stream, IL 60188-2404
630.462.2600 • Fax 630.653.2988

Mr. Mark Abtahi
Stantec
350 N. Orleans St., Suite 1301
Chicago, IL 60654-1983

RE: L-90,964
1909 Raw Water Intake Replacement Project
Evanston, IL

Dear Mr. Abtahi;

Presented in this report are the results of the geotechnical investigation performed for the referenced project. The purpose of this work was to explore soil and ground water conditions to guide in the planning for a proposed water intake system.

For this study one (1) soil boring was performed at the City of Evanston Water Department facility near the shore of Lake Michigan. The borehole was advanced by wet rotary methods and soil samples were collected on 2.5 foot intervals using a standard split spoon or thin walled tube methods. Soil types were logged in the field by the drill crew and representative portions of each sample were placed in glass jars and brought back to our laboratory.

At your direction, several in-situ tests were performed in the borehole at the time it was being drilled. These included field vane shear testing in the soft soils and pressuremeter testing at three (3) intervals.

Field vane shear testing was performed by attaching a 2.5" field vane to the drill string and inserting it into the soil to the desired depth. The drill string was connected to a force arm and rotated using a calibrated drive head. Torque measurements were recorded at 5 degree increments of rotation until the failure occurred at the ultimate shear strength. After a period of several minutes the test was repeated to determine the remolded strength values. The undrained shear strength of the underlying soils at a depth of 33 feet were determined to be 0.84 tsf with a remolded value of 0.4 tsf. The soil sensitivity was calculated to be 2.08 which is typical for the soft clays found in the Chicago area.

Pressuremeter testing was performed at depths of 30 and 40 feet in boring location B-1 by use of a G-AM (Menard) type pressuremeter. The pressuremeter is used to estimate the in-situ stress/strain characteristics of potential foundation bearing materials. Data reductions for the individual tests as well as summary of pressuremeter test results are enclosed with this correspondence.

In the lab, the soil samples were examined and classified according to the Unified Soils Classification System and cohesive soils were measured for moisture content and approximate unconfined compressive strength using a pocket penetrometer. Additional testing requested by Stantec included gradation, Atterberg limits, Specific Gravity and corrosion characteristics. The lab data has been summarized and incorporated into the Boring log.

We are appreciative of the opportunity to assist you with this project. Please feel free to contact me if you have any questions or we may be of further service.

Respectfully Submitted,

TESTING SERVICE CORPORATION

Darin Delaney
Project Geologist

DD/lmz
Enc.

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **1** DATE STARTED **3-17-20** DATE COMPLETED **3-17-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **590.5**

END OF BORING **518.0**

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING **8.0 '**

▽ AT END OF BORING **Rotary Wash**

▼ 24 HOURS

LENGTH RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γ_{DRY}	DEPTH	ELEV.	SOIL DESCRIPTIONS
									FILL - Dark brown to black CLAY with concrete, debris, moist (CL)
	1	SS	4	16.4			3.0	587.5	
	2	SS	3	21.0					FILL - Brown silty SAND and Crushed Concrete, brick, dense (SM)
	3	SS	17	18.7			5.5	585.0	
									FILL - Construction Debris
	4	SS	16	20.1			8.0	582.5	▼
	5	SS	16	16.6					FILL - Brown silty SAND with Crushed Concrete, asphalt, brick, saturated (SM)
	6	SS	10	25.8			13.0	577.5	
	7	SS	22	22.3					Medium dense brown silty fine SAND, trace small gravel, saturated (SM) Sample 6: Gradation 9% Silt and Clay 91% Sand and Gravel
	A			12.2			18.0	572.5	
	8	SS	26	19.4			19.5	571.0	Medium dense brown and gray SAND and GRAVEL, saturated (SP/GP)
	B						20.5	570.0	Medium dense gray SILT, trace sand, clay, moist (ML)
	9	SS	2	44.2	<0.25*				Sample 10: Organic Content: 1.8%
	10	SS	WOH	46.3	<0.25*				Very soft brownish-gray silty CLAY, trace sand, moist (CL/CH)
	11	ST	Push	45.5	0.8 TV=0.08	75.6			Sample 11: LL: 46 PL: 18 PI: 28
	12	SS	WOH	26.4	<0.25*				Sample 13: Gradation 31% Clay, 62% Silt, 7% Sand, 0% Gravel LL: 32 PL: 15 PI: 17 Specific Gravity 2.759 Chloride<50 mg/kg, Sulfate 204 mg/kg, pH 8.38
	13	ST	Push	25.8	0.25 TV=0.15		33.0	557.5	
	14	SS	7	17.1	0.43*				Soft gray silty CLAY, trace sand, small gravel, moist (CL/CH)
	15	SS	4	26.0	<0.25*		35.5	555.0	
	A			24.3	<0.25*				Soft gray silty CLAY, little sand, small gravel, moist (CL/CH)
	16	SS	4	21.8	<0.25*				
	B								

DISTANCE BELOW SURFACE IN FEET

0 5 10 15 20 25 30 35 40

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

DRILL RIG NO. **815**

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **1** DATE STARTED **3-17-20** DATE COMPLETED **3-17-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **590.5**

END OF BORING **518.0**

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING **8.0 '**

▽ AT END OF BORING **Rotary Wash**

▼ 24 HOURS

DISTANCE BELOW SURFACE IN FEET	LENGTH RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γ_{DRY}	DEPTH	ELEV.	SOIL DESCRIPTIONS
40		17	SS	4	25.3	<0.25*				Sample 17: LL: 31 PL: 15 PI: 16 Gradation: 80% Silt and Clay, 20% Sand and Gravel Specific Gravity: 2.719
45		18	SS	5	24.9	<0.25*				
		19	SS	4	23.4	<0.25*				
50		20	SS	7	24.3	<0.25*				Soft gray silty CLAY, little sand, small gravel, moist (CL/CH)
		21	SS	4	23.5	<0.25*				
55		22	SS	9	22.8	<0.25*				
		23	SS	6	22.4	<0.25*				
		24	SS	5	21.6	<0.25*				
60								60.5	530.0	
		25	SS	5	22.5	0.96*				Stiff gray silty CLAY, trace sand, gravel, moist (CL)
65		26	SS	12	15.8	1.0*				
		A			14.3	1.5*				
		27	SS	68/8"						
		B			16.0	2.0*				
								68.0	522.5	
		28	SS	70/9"	13.3	5.32*				Hard gray silty CLAY, little sand, trace gravel, moist (CL)
70		29	SS	100/2"	13.5	4.5+*				
75										End of Boring at 72.5'
										* Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer.
80										Dietrich Auto Hammer #315

DRILL RIG NO. **815**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

TESTING SERVICE CORPORATION
457 East Gundersen Drive
Carol Stream, Illinois

TSC Job No. L-90,964
March 17, 2020

CLIENT: Stantec
350 N. Orleans St., Suite 1301
Chicago, IL 60654-1983

PROJECT: 1909 Raw Water Intake Replacement Project
301 Lincoln St.
Evanston, IL

FIELD VANE SHEAR RESULTS

Boring Number	Approximate Vane Tip Depth (feet)	Approximate Vane Tip Elevation	Peak Su		Remolded Su		Sensitivity
			psf	ksf	psf	ksf	
1	33.0'	557.5	839	0.84	404	0.4	2.08

TSC

Pressuremeter Data Reduction

Project name:	Evanston Water Intake System	Use of a slotted casing:	No
Boring number:	1	Test depth:	30.00 ft
Test date: (mm/dd/yyyy)	03/18/2020	Manometer height above ground:	4.70 ft
Test number:	1	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

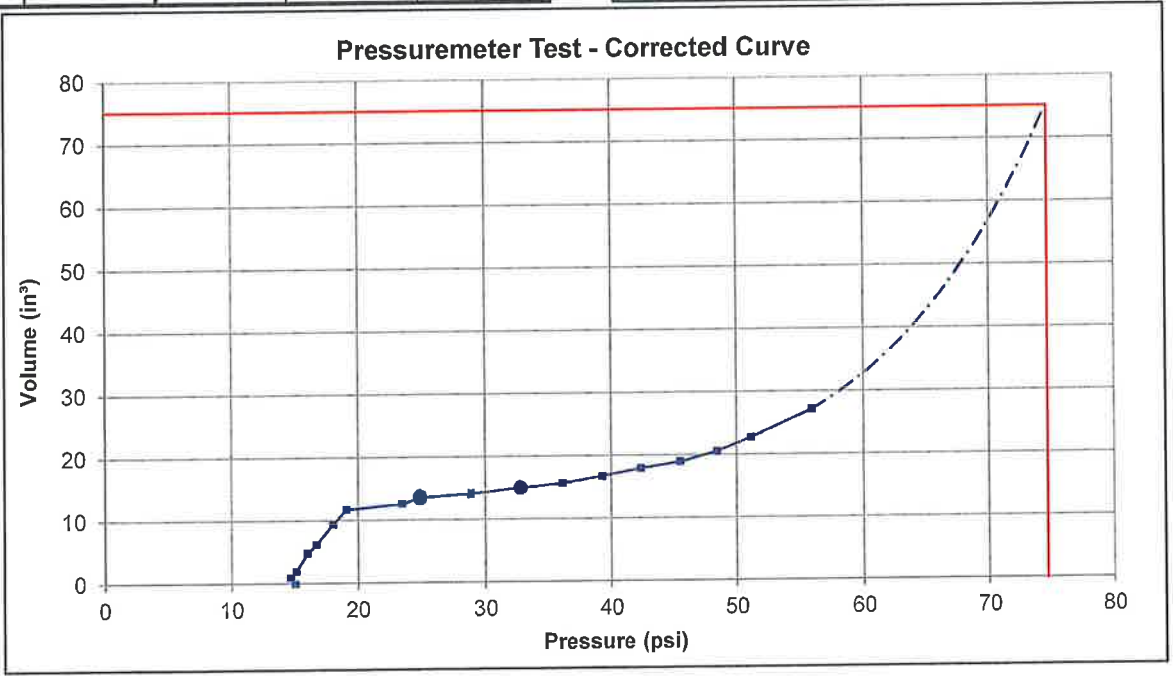
Raw Readings		Corrected Readings		
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %
0	0.0	15	0.0	0.00
4	1.0	15	1.0	1.01
6	2.0	15	2.0	2.01
11	4.9	16	4.9	4.96
13	6.2	17	6.2	6.29
17	9.5	18	9.5	9.41
20	11.8	19	11.8	11.60
25	12.7	23	12.7	12.45
28	13.7	25	13.7	13.35
32	14.2	29	14.1	13.79
36	15.1	33	15.1	14.63
40	15.7	36	15.7	15.23
44	16.8	39	16.8	16.17
47	18.0	42	18.0	17.26
51	19.0	46	19.0	18.17
54	20.6	49	20.6	19.56
58	22.8	51	22.7	21.41
65	27.2	56	27.1	25.12

Test Results

Pressuremeter modulus E:	935 psi
Ultimate pressure P_L:	75 psi
Ratio E / P_L:	12.53
At-rest earth pressure P_O:	20 psi
Creep pressure P_F:	38 psi
Reload modulus E_R:	n.a.
Ratio P_L / P_F:	1.97

Calibration Sheet Reference

Remarks



TSC

Pressuremeter Data Reduction

Project name:	Evanston Water Intake System	Use of a slotted casing:	No
Boring number:	1	Test depth:	40.00 ft
Test date: (mm/dd/yyyy)	03/18/2020	Manometer height above ground:	4.70 ft
Test number:	2	Poisson's coefficient:	0.33
Probe size:	N	Fluid density:	1.000

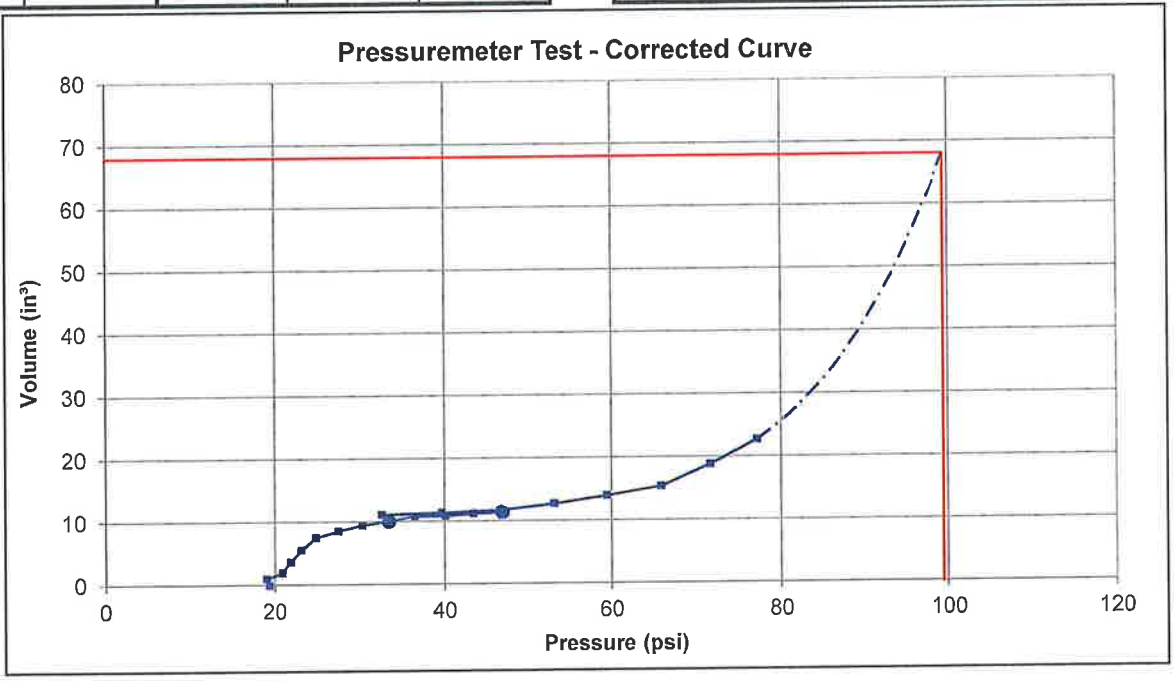
Raw Readings		Corrected Readings			
Pressure psi	Volume in³	Pressure psi	Volume in³	$\Delta R/R_0$ %	
0	0.0	19	0.0	0.00	
4	1.0	19	1.0	1.01	
7	2.0	21	1.9	2.01	
11	3.7	22	3.7	3.74	
15	5.6	23	5.5	5.62	
18	7.5	25	7.5	7.53	
22	8.5	28	8.5	8.53	
25	9.5	30	9.4	9.41	
29	10.1	33	10.1	9.99	◄
33	10.9	37	10.8	10.73	
36	10.9	40	10.9	10.79	
40	11.3	43	11.3	11.13	
44	11.5	47	11.5	11.30	◄
29	11.2	33	11.2	11.02	
36	11.4	40	11.4	11.25	
44	11.8	47	11.8	11.59	
51	12.8	53	12.7	12.49	
58	14.0	59	14.0	13.62	
65	15.4	66	15.4	14.95	
73	18.9	72	18.8	18.00	
80	22.8	77	22.7	21.40	

Test Results

Pressuremeter modulus E:	1,498 psi
Ultimate pressure P_L:	99 psi
Ratio E / P_L:	15.07
At-rest earth pressure P_O:	30 psi
Creep pressure P_F:	55 psi
Reload modulus E_R:	3,660 psi
Ratio P_L / P_F:	1.81

Calibration Sheet Reference

Remarks



TSC Job No. L-90,964 Project : City of Evanston Warer Intake System

SUMMARY OF PRESSUREMETER TEST RESULTS

Boring No.	Depth (feet)	P_O (tsf)	P_F (tsf)	P_L (tsf)	P_L* (tsf)	E (tsf)	E_R (tsf)	E/E_R	E/P_L	E/P_L*	P_L/P_F	Remarks
1	30.0	1.4	2.7	5.4	4.0	67			12.5	17.0	1.97	
1	40.0	2.2	4.0	7.1	5.0	108	263	0.41	15.1	21.7	1.81	
							Average:	0.41	13.8	19.3	1.89	

P_O = at-rest pressure
P_F = creep pressure
P_L = limit pressure
P_L* = net limit pressure
E = pressuremeter modulus
E_R = reload modulus

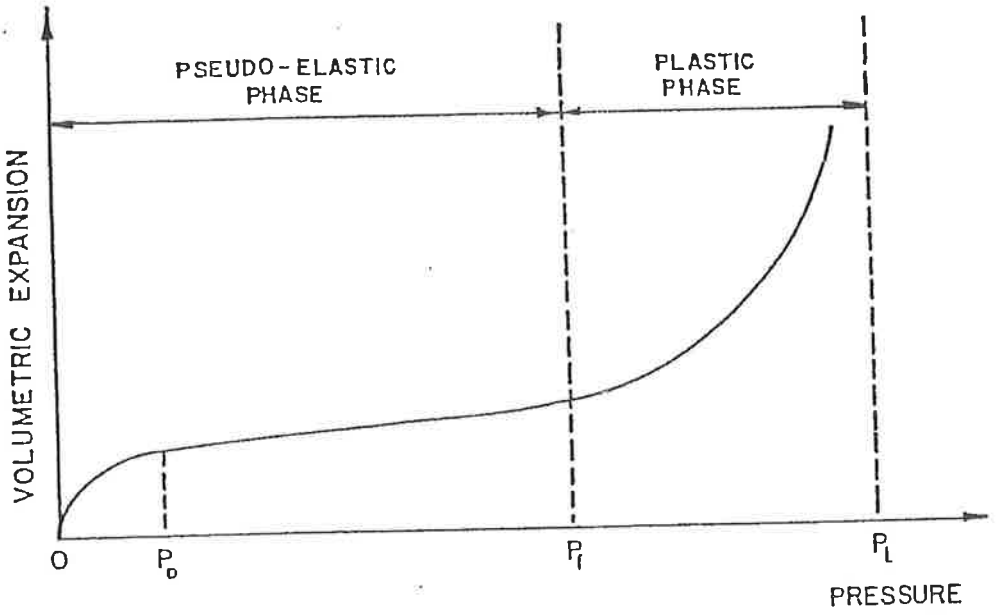
PRESSUREMETER INVESTIGATION

The pressuremeter is essentially used to perform an in-situ load test. It allows for the determination of the stress-strain characteristics of soil or rock with depth. Its results are most commonly used in the determination of bearing capacity for foundations and also in the evaluation of settlement.

Testing Service Corporation uses a Menard Pressuremeter, Model G-Am manufactured by Roctest. The downhole probe fits in NX size casing, measuring approximately 2.75 inches in diameter. Its overall length is approximately 2.25 feet.

To perform a pressuremeter test, the cylindrical probe is lowered into a bore hole to the desired test depth. A flexible cell contained in the probe is then expanded against the sides of the hole by applying internal gas pressure. The deformation of the surrounding soil or rock is measured by means of volume changes in the test cell. Pressure is increased incrementally, with volume readings typically taken at 30 and 60 seconds.

The results of the pressuremeter test are generally interpreted by plotting pressure versus volume change for each loading increment. A typical curve is shown below. It can typically be divided into three parts in conformance with Menard's theories.



The elastic zone in which soil strengths are completely recoverable is generally not noticed due to drilling disturbance. The lower limit of this elastic zone is defined as p_o. It corresponds to seating of the probe against the sides of the bore hole.

At pressures above p_o, the soil behaves as a pseudo-elastic material which is indicated as a straight line on the curve. Strains occurring within this zone are not completely recoverable. The linearity of this portion of the curve helps define the modulus of deformation for the soil, which in turn can be used for settlement evaluation. The upper limit of the pseudo-elastic zone is defined as p_f.

Creep deformation of the soil occurs at pressures above p_f. The pressure at which failure eventually occurs is defined as the limit pressure or P_L. It is normally related to the ultimate bearing capacity of the soil.

The following values are those usually obtained from the pressure versus volume curves and used in the foundation analysis:

Limit Pressure (PL) - Pressure at which failure occurs in tons per square foot

Modulus of Deformation (E) - Slope of stress-strain curve for the pseudo-elastic zone in tons per square foot.

Bearing capacity can be derived from the pressuremeter data using the following general equation:

$$q = P_V + k\,(P_L - P_o)$$

where q = Ultimate bearing capacity

P_o = Lateral at-rest pressure of the soil at the elevation of the foundation element

P_L = Limit pressure of the soil

k = A coefficient which depends upon soil type, geometric shape of the foundation, and depth of embedment

P_V = Overburden pressure at foundation level

Settlement calculations are based on the following computation:

$$S = \frac{1.33}{3E}\, P\, Ro\, (\lambda\, 2\, \frac{R}{Ro})^{\alpha} + \frac{\alpha}{4.5E}\, P\, \lambda\, 3R$$

where E = Pressuremeter modulus

P = Contact stress at base of foundation

R = Radius of foundation

Ro = Reference length of 30 cm

α = Rheologic coefficient based on type of soil

$\lambda\ 2/3$ = Shape coefficients

The above is intended to be a summary of pressuremeter testing, i.e. field procedures, data reduction and analysis. The List of References which follows may be referred to for more detailed information.

REFERENCES

1. The Menard Pressuremeter - Interpretation and Application of Pressuremeter Test Results - Sols Soils No. 26-1975

2. Baguelin F., Jezequel J.f., Shields D.H, The Pressuremeter and Foundation Engineering, Trans Tech Publications, 1978

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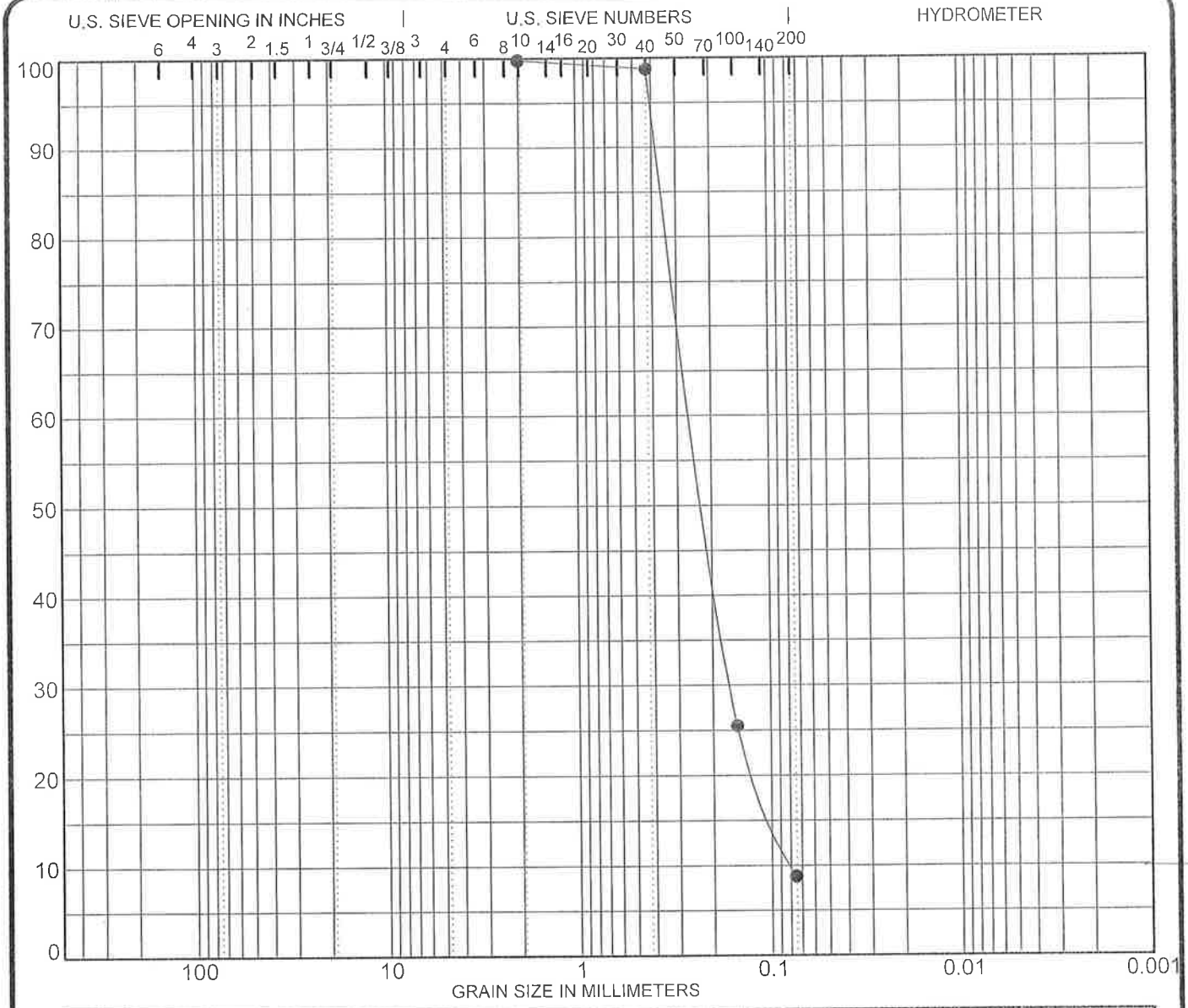
5. Lukas R.G., de Bussy, B.L., "Pressuremeter and Laboratory Test Correlations for Clays", ASCE Journal of the Geotechnical Engineering Division Vol 102, No. GT9, September 1976

6. Briaud J-L, Lytton R.L., Hung J-T, "Obtaining Moduli from Cyclic Pressuremeter Tests", ASCE Journal of Geotechnical Engineering Vol. 109, No. 5, May 1983

7. Orpwood T.G., Ahmad S.A., Peaker K.R., "Pressuremeter Evaluation of Glacial Till Bearing Capacity in Toronto, Canada", Proceedings of the 1989 Foundation Engineering Congress, Foundation Engineering: Current Principles and Practices Vol.1, 1989

8. Lutenegger A.J., "Use of In-Situ Tests to Determine Design Parameters for Drilled Shaft Foundations"

9. Haberfield C.M., Johnston I.W., "Model Studies of Pressuremeter Testing in Soft Rock", Geotechnical Testing Journal, Vol. 12, No. 2, June 1989



COBBLES	GRAVEL		SAND			ASTM D 422
	coarse	fine	coarse	medium	fine	

SPECIMEN IDENTIFICATION	SIEVE	% PASS
Boring: 1	3"	100.0
Sample: 6	2"	100.0
	1-1/2"	100.0
	1"	100.0
NOTES :	3/4"	100.0
	3/8"	100.0
	#4	100.0
	#10	99.8
	#40	98.8
	#100	25.5
	#200	8.8

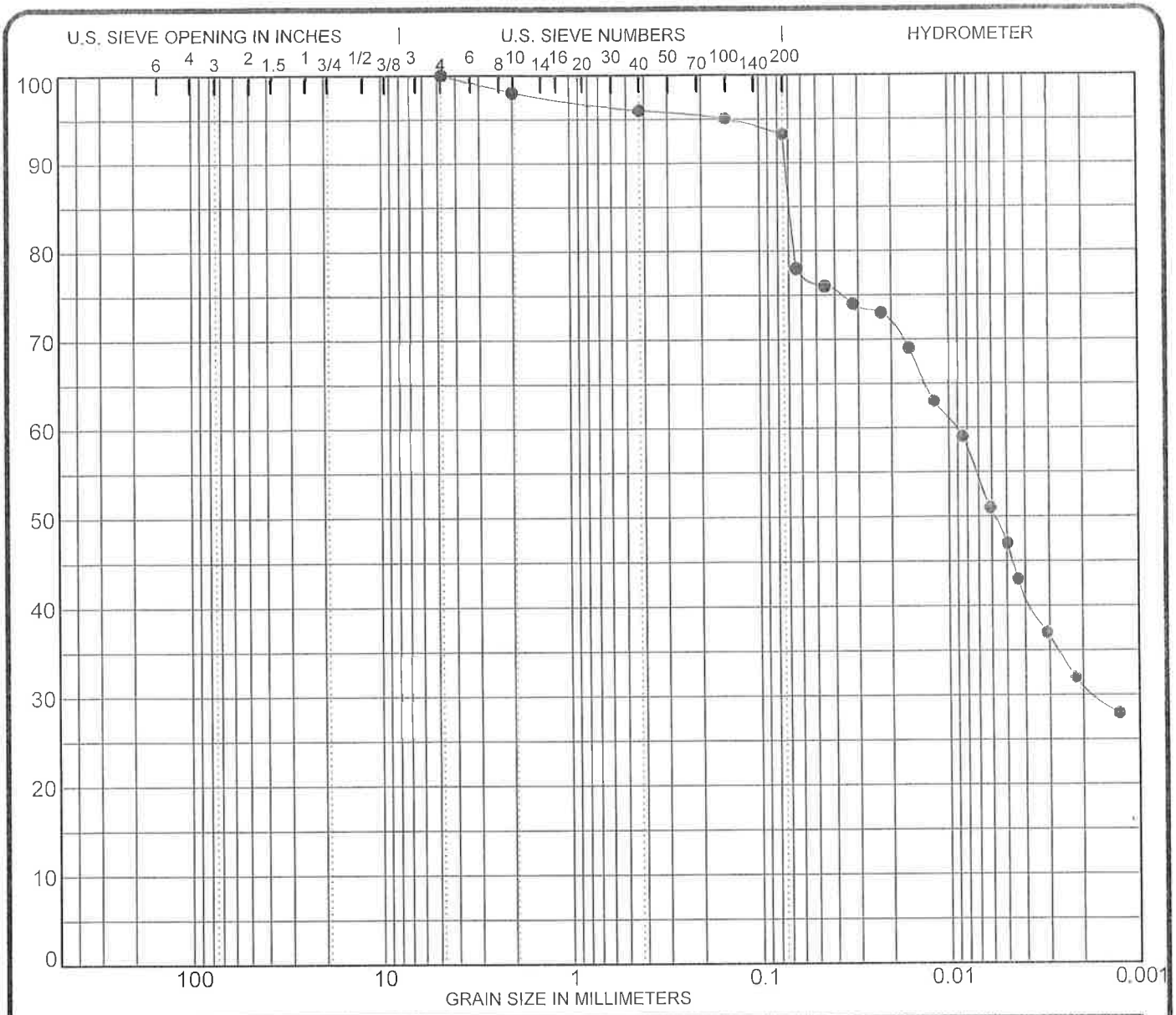
PROJECT City of Evanston Water Intake System Borings
LOCATION Evanston, Illinois
JOB NO. L - 90,964
DATE April 9, 2020

1

GRADATION SHEET

Testing Service Corporation
Carol Stream, IL 60188

ASTMD422 90964.GPJ TSC ALL.GDT 4/9/20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SPECIMEN IDENTIFICATION	SIEVE	% PASS
Boring: 1	3 inch	100
Sample: 13	2	100
	1 1/2	100
	1	100
NOTES:	3/4	100
	3/8	100
	# 4	100
	# 10	98
	# 40	96
	# 100	95
	# 200	93

SOIL CLASSIFICATION: Gray silty CLAY, trace sand (CL)

%GRAVEL	%SAND	%SILT	%CLAY
0	7	62	31

		LL	PL	PI
		32	15	17

	SpGr		
	2.759		

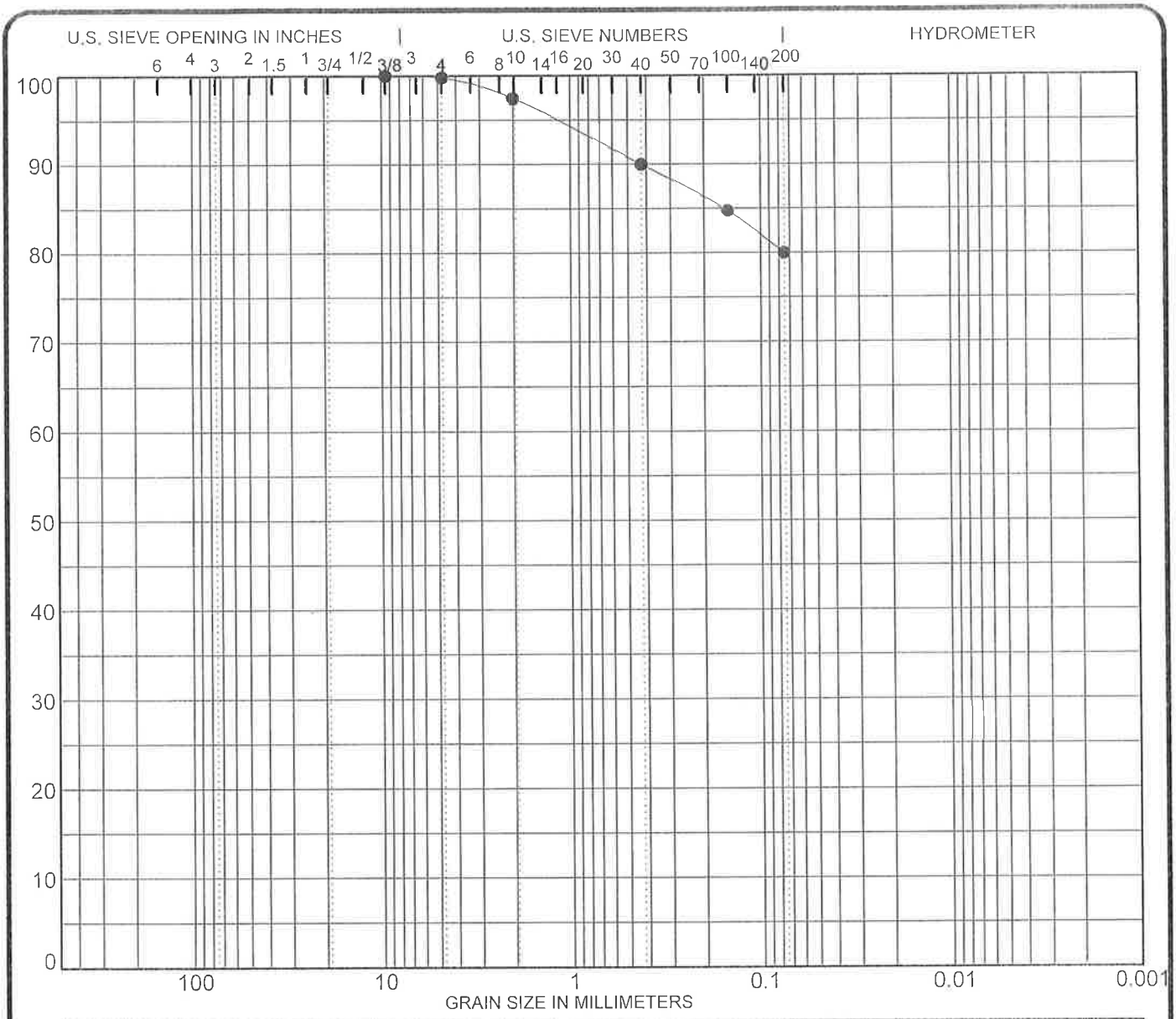
PROJECT City of Evanston Water Intake System Borings
LOCATION Evanston, Illinois
JOB NO. L - 90,964
DATE April 9, 2020

1

SOIL DATA SHEET

Testing Service Corporation
Carol Stream, IL 60188

SOILGENR 90964.GPJ TSC ALL.GDT 4/14/20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

SPECIMEN IDENTIFICATION	SIEVE	% PASS
Boring: 1	3 inch	100
Sample: 17	2	100
	1 1/2	100
	1	100
NOTES:	3/4	100
	3/8	100
	# 4	100
	# 10	97
	# 40	90
	# 100	85
	# 200	80

SOIL CLASSIFICATION

Gray silty CLAY, little sand (CL)

%GRAVEL	%SAND	%SILT	%CLAY
0	20	(80% Combined)	

		LL	PL	PI
		31	15	16

	SpGr		
	2.719		

PROJECT City of Evanston Water Intake System Borings
LOCATION Evanston, Illinois

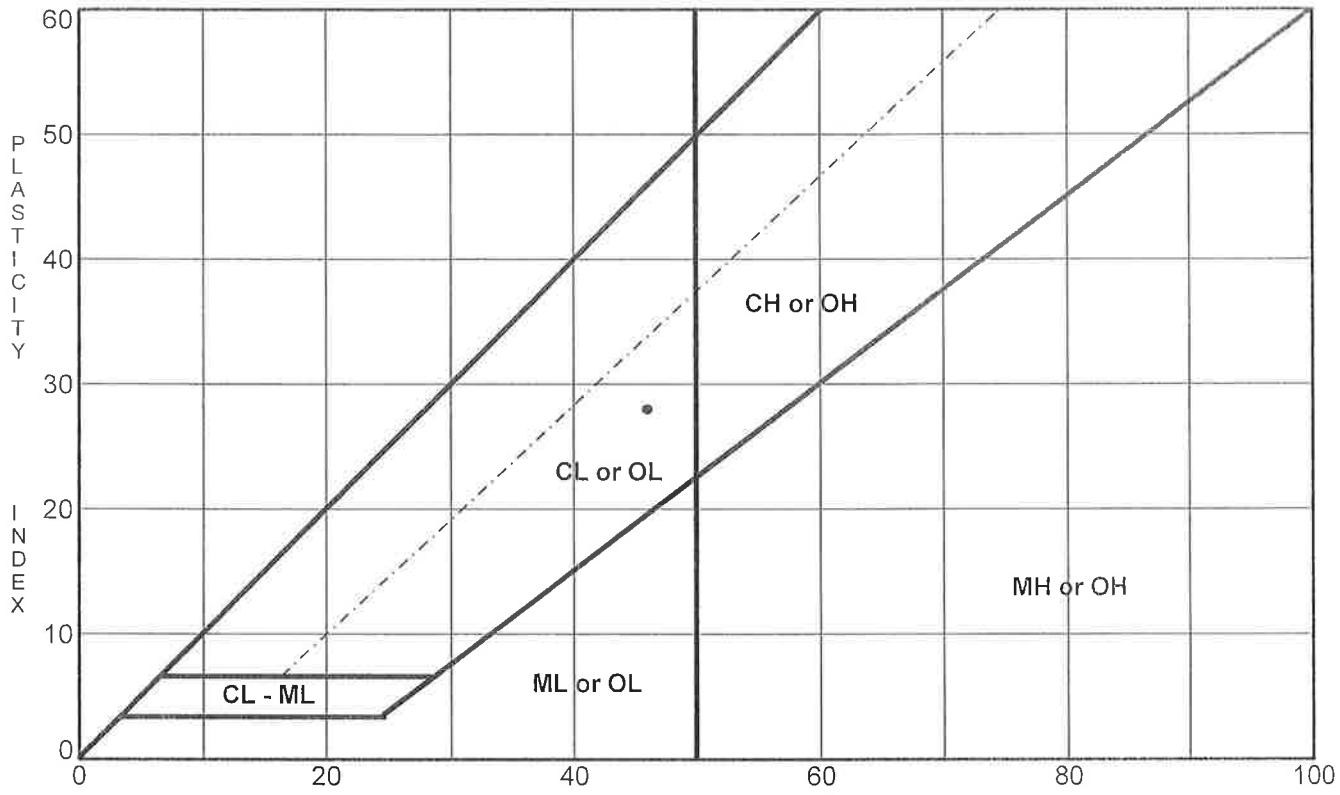
JOB NO. L - 90,964
DATE April 9, 2020

1

SOIL DATA SHEET

Testing Service Corporation
Carol Stream, IL 60188

SOILGENR 90964.GPJ TSC ALL.GDT 4/14/20



LIQUID LIMIT

ASTM D 4318

LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
46	**18**	**28**	

SPECIMEN IDENTIFICATION	SOIL CLASSIFICATION
Boring: 1	Brownish gray silty CLAY (CL)
Sample: 11	

PROJECT :	**City of Evanston Water Intake System Borings**	**JOB NO :**	**L - 90,964**
CITY,STATE :	**Evanston, Illinois**	**DATE :**	**April 9, 2020**

ATTERBERG LIMITS

Testing Service Corporation

Carol Stream, IL 60188

1

ATLIMITS 90964.GPJ TSC ALL.GDT 4/9/20

First Environmental Laboratories, Inc.
IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

April 10, 2020

Mr. Darin Delaney
TESTING SERVICE CORP.
360 S. Main Place
Carol Stream, IL 60188

Project ID: 90964
First Environmental File ID: 20-1837
Date Received: April 07, 2020

Dear Mr. Darin Delaney:

The above referenced project was analyzed as directed on the enclosed chain of custody record.

All Quality Control criteria as outlined in the methods and current IL ELAP/NELAP have been met unless otherwise noted. QA/QC documentation and raw data will remain on file for future reference. Our accreditation number is 100292 and our current certificate is number 1002922019-1: effective 08/22/2019 through 04/30/2020.

I thank you for the opportunity to be of service to you and look forward to working with you again in the future. Should you have any questions regarding any of the enclosed analytical data or need additional information, please contact me at (630) 778-1200.

Sincerely,

Joy Geraci
Project Manager

First Environmental Laboratories, Inc.
IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Case Narrative

TESTING SERVICE CORP.

Project ID: **90964**

Lab File ID: **20-1837**

Date Received: **April 07, 2020**

All quality control criteria, as outlined in the methods, have been met except as noted below or on the following analytical report.

The results in this report apply to the samples in the following table:

Laboratory Sample ID	Client Sample Identifier	Date/Time Collected
20-1837-001	S-13	4/6/2020 10:00

Sample Batch Comments:

Sample acceptance criteria were met.

Method Comments

Lab Number	Sample ID	Comments:
20-1837-001	S-13	*Chloride, Soluble* Matrix spike recovery outside control limits low bias; LCS acceptable.

First Environmental Laboratories, Inc.
IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Case Narrative

TESTING SERVICE CORP.

Lab File ID: **20-1837**

Project ID: **90964**

Date Received: **April 07, 2020**

All quality control criteria, as outlined in the methods, have been met except as noted below or on the following analytical report.

The following is a definition of flags that may be used in this report:

Flag	Description	Flag	Description
A	Method holding time is 15 minutes from collection. Lab analysis was performed as soon as possible.		
B	Analyte was found in the method blank.	L	LCS recovery outside control limits.
<	Analyte not detected at or above the reporting limit.	M	MS recovery outside control limits; LCS acceptable.
C	Sample received in an improper container for this test.	P	Chemical preservation pH adjusted in lab.
D	Surrogates diluted out; recovery not available.	Q	Result was determined by a GC/MS database search.
E	Estimated result; concentration exceeds calibration range.	S	Analysis was subcontracted to another laboratory.
G	Surrogate recovery outside control limits.	T	Result is less than three times the MDL value.
H	Analysis or extraction holding time exceeded.	W	Reporting limit elevated due to sample matrix.
J	Estimated result; concentration is less than routine RL but greater than MDL.	N	Analyte is not part of our NELAC accreditation or accreditation may not be available for this parameter.
RL	Routine Reporting Limit (Lowest amount that can be detected when routine weights/volumes are used without dilution.)	ND	Analyte was not detected using a library search routine; No calibration standard was analyzed.

First Environmental Laboratories, Inc.
IL ELAP / NELAC Accreditation # 100292
1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Analytical Report

Client: TESTING SERVICE CORP.
Project ID: 90964
Sample ID: S-13
Sample No: 20-1837-001

Date Collected: 04/06/20
Time Collected: 10:00
Date Received: 04/07/20
Date Reported: 04/10/20

Results are reported on a dry weight basis.

Analyte	Result	R.L.	Units	Flags
Solids, total **Method: 2540B**				
Analysis Date: 04/07/20				
Total Solids	79.22		%	
Chloride, Soluble **Method: 4500CL,C 1999**				
Analysis Date: 04/08/20				
Chloride, Soluble	< 50	50	mg/kg	N
pH @ 25°C, 10% solution **Method: 9045D 2004**				
Analysis Date: 04/09/20 15:30				
pH @ 25°C, 10% solution	8.38		Units	
Sulfate, Soluble **Method: 9038**				
Analysis Date: 04/09/20				
Sulfate, Soluble	204	150	mg/kg	N

CHAIN OF CUSTODY RECORD

Page___ of ___ pgs

First Environmental Laboratories, Inc.

First Environmental Laboratories
1600 Shore Road, Suite D
Naperville, Illinois 60563
Phone: (630) 778-1200 • Fax: (630) 778-1233
E-mail: firstinfo@firstenv.com • www.firstenv.com
IEPA Certification #100292

Company Name: TSC

Street Address:

City: State: Zip:

Phone: e-mail: ddelaney@tsccorp.com

Send Report To: Darin Delaney

Sampled By: Darin Delaney

Project I.D.: 90964

P.O. #:

20.1837

Date/Time Taken	Sample Description	Matrix	Parameter(s): Sulphate	Chloride	pH						Hold – Do Not Analyze	Comments	Lab I.D.
April 6, 2020 16:00	S-13	Soil	X	X	X								001

FOR LAB USE ONLY:

Cooler Temperature: 0.1-6°C Yes X No.__ 4.7 °C
Received within 6 hrs. of collection:____
Ice Present: Yes__ No X

LAB COURIER USE ONLY:

Sample Refrigerated: Yes__ No__
Refrigerator Temperature:____°C

Program: ☐ TACO/SRP ☐ CCDD ☐ NPDES ☐ LUST ☐ SDWA

*Matrix Code Key: S-Soil SL-Sludge DW-Drinking Water WW-Wastewater GW-Groundwater WIPE-Wipe O-Other

Notes and Special Instructions:

Relinquished By: Darin D. Delaney Date/Time 4/7/20 11:30 Received By: [signature] Date/Time 04/07/20 11:30

Relinquished By: Date/Time Received By: Date/Time

Rev. 6/19

LEGEND

SOIL BORING LOCATION

BORING LOCATION PLAN
WATER INTAKE PROJECT
EVANSTON WATER DEPARTMENT
EVANSTON, ILLINOIS

TSC

TESTING SERVICE CORPORATION
457 EAST GUNDERSEN DRIVE
CAROL STREAM, ILLINOIS 60188

DRAWN BY:	TJF
CHECKED BY:	DPD
JOB NO.:	L-90,964
DATE:	04-17-20

PAGE NO.
1 OF 1

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Appendix B

Offshore Geotechnical Data Report

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TESTING SERVICE CORPORATION

Corporate Office:
360 S. Main Place, Carol Stream, IL 60188-2404
630.462.2600 • Fax 630.653.2988

Local Office:
457 E. Gundersen Drive, Carol Stream, IL 60188-2492
630.653.3920 • Fax 630.653.2726

August 27, 2020
Local Office

Mr. Mark Abtahi
Stantec
350 N. Orleans St., Suite 1301
Chicago, IL 60654-1983

RE: L-90,964
Lake Borings
1909 Raw Water Intake Replacement Project
Evanston, IL

Dear Mr. Abtahi;

Presented in this report are the results of the geotechnical investigation performed for the referenced project. The purpose of this work was to explore soil and ground water conditions to guide in the planning for a proposed water intake system.

For this phase of the study six (6) soil borings were performed in Lake Michigan near the City of Evanston Water Department facility. They are designated LB-2 through LB-7 and start at a point 1000 feet off the shoreline and extend on a line to the east at 1000 foot intervals. Boring location coordinates were determined in the field using a Trimble R8S GNSS receiver. A Boring Location Plan including GPS state plane coordinates and elevations referenced to NAD 83 is enclosed for your records.

The boreholes were accessed with a truck mounted drill on the deck of a spud barge provided by Big Lake Marine. Water depths at the time of the drilling ranged from 20 feet at the west end to 36 feet at the farthest east boring location. They were advanced by auger methods and soil samples were collected on 2.5 foot intervals using a standard split spoon or thin walled tube methods. Soil types were logged in the field by the drill crew and representative portions of each sample were placed in glass jars and brought back to our laboratory.

In the lab, the split spoon and Shelby tube samples were examined and classified according to the Unified Soils Classification System and cohesive soils were measured for moisture content and approximate unconfined compressive strength using a pocket penetrometer or by direct methods. Additional testing requested by Stantec included gradation, Atterberg limits, Specific Gravity, direct shear and corrosion characteristics. Direct Shear tests were performed using the methods directed by the client and vary from our normal ASTM procedures. The lab data has been summarized and incorporated into the Boring Logs and/or individual Soil Test Data Sheets.

The majority of the borings were drilled to a depth of 20 to 30 feet below the lake bottom and consisted mainly of very soft to soft gray silty Clay with compressive strength values of less than 0.25 TSF. One (1) of the borings, LB-5, was extended to a depth of 59 feet below lake bottom. At this location very stiff to hard gray silty Clay was encountered at a depth of 43 feet. The borehole was terminated on a possible boulder or limestone bedrock at a depth of 58 feet or elevation 492.5. Boring Logs including laboratory data have been prepared and are enclosed.

We are appreciative of the opportunity to assist you with this project. Please feel free to contact me if you have any questions or we may be of further service.

Respectfully Submitted,

TESTING SERVICE CORPORATION

Darin Delaney
Project Geologist

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB2** DATE STARTED **7-28-20** DATE COMPLETED **7-28-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **563.5 (Lake Bottom)**

END OF BORING **543.5**

Water Depth - 20 Feet

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING

▽ AT END OF BORING

▼ 24 HOURS

SAMPLE NO.	SAMPLE TYPE	LENGTH RECOVERY	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS		WOH	49.0	0.26		0.05			Very soft gray silty CLAY, very moist. (CL)
2	SS		WOH	44.7	0.19		0.05			Sample 2: Seive Analysis % Gravel = 0.0 % Sand = 0.0 % Silt and Clay = 100
3	SS		WOH	23.6	<0.25*		0.05	7.0	556.5	
4	ST		PUSH	24.4	0.14	97.0	0.14			Very soft gray silty CLAY, little sand, trace gravel, moist. (CL)
5	SS		3	21.4	0.19		0.13			Sample 4: Seive Analysis % Gravel = 1.0 % Sand = 16.0 % Silt = 53.0 % Clay = 30.0
6	SS		2	22.7	0.19		0.05			
7	SS		2	20.3	0.25*		0.15			Sample 4: Atterberg Limits LL = 29.0 PL = 14.0 PI = 15.0
8	SS		2	22.8	0.25*		0.2			

End of Boring at 20.0'

* Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer.

Diedrich Auto Hammer #315

Depths and elevations are referenced from lake bottom.

Northing	1965629.821
Easting	1164413.756
Lake Elevation	586.5

DISTANCE BELOW SURFACE IN FEET

0 5 10 15 20 25 30 35 40

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

EXTRA 90964.GPJ TSC_ALL.GDT 9/21/20

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB3** DATE STARTED **7-28-20** DATE COMPLETED **7-28-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **561.0 (Lake Bottom)**

END OF BORING **541.0**

Water Depth - 22 Feet

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING

▽ AT END OF BORING

▼ 24 HOURS

SAMPLE NO.	SAMPLE TYPE	LENGTH RECOVERY	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS		1	29.3	0.13		0.05			Very soft gray silty CLAY, trace sand, very moist. (CL)
2	SS		WOH	50.4	0.06		0.05			Sample 2: Seive Analysis % Gravel = 0.0 % Sand = 1.0 % Silt and Clay = 99.0
3	SS		WOH	27.1	0.06		0.05			Sample 4: Seive Analysis % Gravel = 0.0 % Sand = 5.0 % Silt = 43.0 % Clay = 52.0
4	ST		PUSH	42.9	0.08	73.0				Sample 4: Atterberg Limits LL = 41.0 PL = 17.0 PI = 24.0
5	SS		WOH	38.4	<0.25*		0.05			
								13.0	548.0	
6	SS		WOH	28.1	<0.25*		0.05			Very soft gray silty CLAY, little sand, trace gravel, very moist. (CL)
7	SS		2	24.2	0.13		0.15			Sample 6: Seive Analysis % Gravel = 3.0 % Sand = 16.0 % Silt and Clay = 81.0
8	SS		1	23.5	0.19		0.1			
										End of Boring at 20.0'

* Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer.

Diedrich Auto Hammer #315

Depths and elevations are referenced from lake bottom.

Northing	1965848.277
Easting	1165189.444
Lake Elevation	586.0

DISTANCE BELOW SURFACE IN FEET

0 5 10 15 20 25 30 35 40

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

EXTRA 90964.GPJ TSC_ALL.GDT 9/21/20

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB4** DATE STARTED **7-28-20** DATE COMPLETED **7-28-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **558.0 (Lake Bottom)**

END OF BORING **538.0**

Water Depth - 25 Feet

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING

▽ AT END OF BORING

▼ 24 HOURS

SAMPLE NO.	SAMPLE TYPE	LENGTH RECOVERY	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
								0	558.0	Very soft gray silty CLAY, Some sand, trace gravel, moist. (CL)
1	SS		12	20.6	0.15		0.2			Sample 2: Seive Analysis % Gravel = 1.0 % Sand = 22.0 % Silt and Clay = 77.0
2	SS		3	18.5	0.25*		0.2			
								5.5	552.5	Medium stiff to stiff gray very silty CLAY, little sand, trace gravel, occasional silt seams, moist. (CL)
3	SS		10	16.5	1.75*		0.35			Sample 4: Seive Analysis % Gravel = 5.0 % Sand = 22.0 % Silt = 50.0 % Clay = 23.0
4	ST		PUSH	21.6	0.87	107.0				
								10.5	547.5	
5	SS		4		0.5*		0.25			Soft gray silty CLAY, little sand, trace gravel, moist. (CL)
6	SS		2	64.5	0.57		0.3			Sample 6: Atterberg Limits LL = 31.0 PL = 15.0 PI = 16.0
7	SS		2	22.0	0.51		0.25			
8	SS		2	21.7	0.45		0.10			
										End of Boring at 20.0'

* Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer.

Diedrich Auto Hammer #315

Depths and elevations are referenced from lake bottom.

Northing 1965843.517

Easting 1166456.267

Lake Elevation 586.0

DISTANCE BELOW SURFACE IN FEET

0 5 10 15 20 25 30 35 40

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

EXTRA 90964.GPJ TSC_ALL.GDT 9/21/20

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB5** DATE STARTED **7-29-20** DATE COMPLETED **7-29-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **550.5 (Lake Bottom)**

END OF BORING **491.5**

Water Depth - 33 Feet

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING

▽ AT END OF BORING

▼ 24 HOURS

SAMPLE NO.	SAMPLE TYPE	LENGTH RECOVERY	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
1	SS		WOH	28.9	<0.37		0.15			
2	SS		WOH	33.1	<0.25*		0.10			
3	SS		WOH	29.5	<0.25*		0.10			
4	ST		PUSH	37.8	0.10	83.0				Sample 4: Seive Analysis % Gravel = 0.0 % Sand = 11.0 % Silt = 43.0 % Clay = 46.0
5	SS		WOH	40.6	<0.25*		0.05			
6	SS		WOH	19.8	<0.25*		0.05			Sample 6: Seive Analysis % Gravel = 7.0 % Sand = 12.0 % Silt and Clay = 81.0
7	SS		WOH	31.1	<0.25*		0.05			
8	SS		4	20.8	<0.25*		0.05			Very soft gray silty CLAY, trace to little sand, occasional small gravel, very moist (CL)
9	SS		4	21.9	<0.37		0.05			
10	SS		5	17.3	<0.25*		0.10			
11	SS		4	20.9	<0.25*		0.10			
								38.0	512.5	
12	SS		10	18.7	0.70		0.15			Medium stiff gray silty CLAY, little sand, trace gravel, moist. (CL)

DISTANCE BELOW SURFACE IN FEET

0 5 10 15 20 25 30 35 40

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB5** DATE STARTED **7-29-20** DATE COMPLETED **7-29-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **550.5 (Lake Bottom)**

END OF BORING **491.5**

Water Depth - 33 Feet

WATER LEVEL OBSERVATIONS

WHILE DRILLING

AT END OF BORING

24 HOURS

SAMPLE NO.	SAMPLE TYPE	LENGTH RECOVERY	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
										Medium stiff gray silty CLAY, little sand, trace gravel, moist. (CL)
								43.0	507.5	
13	SS		39	11.4	4.5+*					Very stiff to hard gray silty CLAY, some sand, trace gravel, moist. (CL)
14	SS		54							Sample 13: Seive Analysis % Gravel = 5.0 % Sand = 34.0 % Silt and Clay = 61.0
15	SS		50							
16	SS		50/4"							
								53.0	497.5	
17	SS		54	11.2	2.0*					Very dense clayey SILT with clay layers, little sand, trace gravel, moist. (ML-CL)
								58.0	492.5	
18	SS		50/4"	10.6						Possible Boulder zone or Weathered Dolomite.
										End of Boring at 59.0'

* Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer.

Diedrich Auto Hammer #315

Depths and elevations are referenced from lake bottom.

Northing	1966027.996
Easting	1167381.041
Lake Elevation	586.5

DISTANCE BELOW SURFACE IN FEET

40 45 50 55 60 65 70 75 80

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB6** DATE STARTED **7-27-20** DATE COMPLETED **7-27-20** JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **549.0**

END OF BORING **519.0**

Water Depth - 34 Feet

WATER LEVEL OBSERVATIONS

WHILE DRILLING

AT END OF BORING

24 HOURS

LENGTH RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
	1	SS	2	48.8	<0.25*					
	2	SS	2	45.3	<0.25*					
	3	SS	1	44.4	<0.25*					Sample 3: Seive Analysis % Gravel = 0.0 % Sand = 4.0 % Silt and Clay = 96.0
	4	SS	WOH	37.4	<0.25*					Very soft gray silty CLAY, trace to little sand, trace gravel, very moist. (CL)
	5	ST	PUSH	25.7	0.13	96.0				Sample 5: Seive Analysis % Gravel = 2.0 % Sand = 18.0 % Silt = 46.0 % Clay = 34.0
	6	SS	2	24.7	<0.25*					
	7	SS	3	24.6	<0.25*					Sample 5: Atterberg Limits LL = 30.0 PL = 14.0 PI = 16.0
	8	SS	2	25.7	<0.25*					
	9	SS	3	23.7	<0.37*					
								27.0	522.0	Very soft gray silty CLAY, some sand, trace gravel, moist. (CL)
	10	SS	3	22.4	<0.37*					Sample 10: Seive Analysis % Gravel = 3.0 % Sand = 25.0 % Silt and Clay = 72.0
										End of Boring at 30.0'

* Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer.

Diedrich Auto Hammer #315
Depths and elevations are referenced from lake bottom.

Northing	1966171.749
Easting	1168406.208
Lake Elevation	586.0

DISTANCE BELOW SURFACE IN FEET

0, 5, 10, 15, 20, 25, 30, 35, 40

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

EXTRA 90964.GPJ TSC_ALL.GDT 9/21/20

PROJECT **1909 Raw Water Intake Replacement, Evanston, Illinois**

CLIENT **Stantec, Chicago, Illinois**

BORING **LB7** DATE STARTED _____ DATE COMPLETED _____ JOB **L - 90,964**

ELEVATIONS

GROUND SURFACE **551.0**

END OF BORING **521.0**

Water Depth - 32 Feet

WATER LEVEL OBSERVATIONS

▼ WHILE DRILLING _____

▽ AT END OF BORING _____

▼ 24 HOURS _____

DISTANCE BELOW SURFACE IN FEET

LENGTH RECOVERY	SAMPLE NO.	SAMPLE TYPE	N	WC	Qu	γ DRY	Tv	DEPTH	ELEV.	SOIL DESCRIPTIONS
								0.5	550.5	Loose brown clayey SILT, saturated. (ML)
	A 1 B	SS	2	16.1 20.7	0.43					Soft to stiff gray silty CLAY, little to some sand, trace gravel, moist. (CL) Sample 2: Seive Analysis % Gravel = 2.0 % Sand = 21.0 % Silt and Clay = 77.0 Sample 4: Seive Analysis % Gravel = 1.0 % Sand = 21.0 % Silt and Clay = 78.0
	2	SS	5	18.6	0.70					
	3	SS	5	18.0						
	4	SS	10	23.3	0.43					
								10.5	540.5	
	5	SS	4	23.1	0.25*					Very soft gray silty CLAY, little to some sand, trace gravel, very moist. (CL) Sample 7: Seive Analysis % Gravel = 2.0 % Sand = 22.0 % Silt = 44.0 % Clay = 32.0 Sample 10: Seive Analysis % Gravel = 1.0 % Sand = 20.0 % Silt and Clay = 79.0
	6	SS	4	22.1	<0.25*					
	7	ST	PUSH	23.1	0.11	98.0				
	8	SS	4	24.7	<0.25*					
	9	SS	5	22.8	<0.37					
	10	SS	4	24.0	<0.25*					
	11	SS	10	22.9	<0.25*					End of Boring at 30.0' * Approximate unconfined compressive strength based on measurements with a calibrated pocket penetrometer. Diedrich Auto Hammer #315 Depths and elevations are referenced from lake bottom. Northing 1966347.388 Easting 1169031.374 Lake Elevation 586.0

DRILL RIG NO. **315**

Division lines between deposits represent approximate boundaries between soil types; in-situ, the transition may be gradual.

EXTRA 90964.GPJ TSC_ALL.GDT 9/21/20

DEMANDSTAR

Building Communities.

(E-bidding) Electronic Bidding Instructions

Introduction

To submit a bid electronically (e-bidding) on DemandStar

- The project **MUST** be setup for e-bidding by the government agency advertising the opportunity

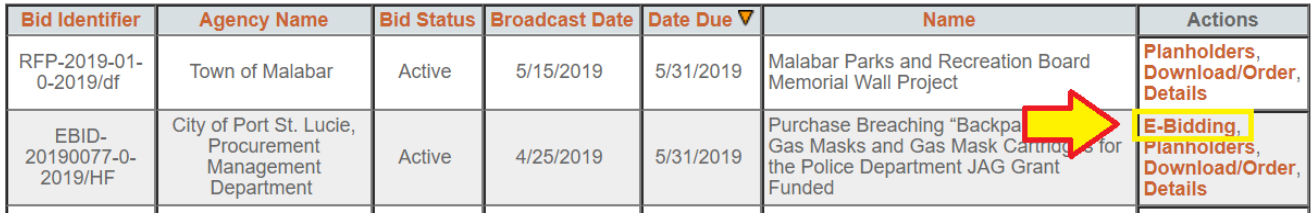
Bid Identifier	Agency Name	Bid Status	Broadcast Date	Date Due	Name	Actions
RFP-2019-01-0-2019/df	Town of Malabar	Active	5/15/2019	5/31/2019	Malabar Parks and Recreation Board Memorial Wall Project	Planholders, Download/Order, Details
EBID-20190077-0-2019/HF	City of Port St. Lucie, Procurement Management Department	Active	4/25/2019	5/31/2019	Purchase Breaching "Backpa... Gas Masks and Gas Mask Cartridg...s for the Police Department JAG Grant Funded	E-Bidding, Planholders, Download/Order, Details

How to check if it is an e-bidding opportunity

- Not all opportunities posted on DemandStar by government are available for e-bidding
- Those that are available for you to electronically bid will list "e-bidding" as an available "ACTION" when you look at the project details

In order to do e-bidding

1. Click on “E-bidding” in the actions column

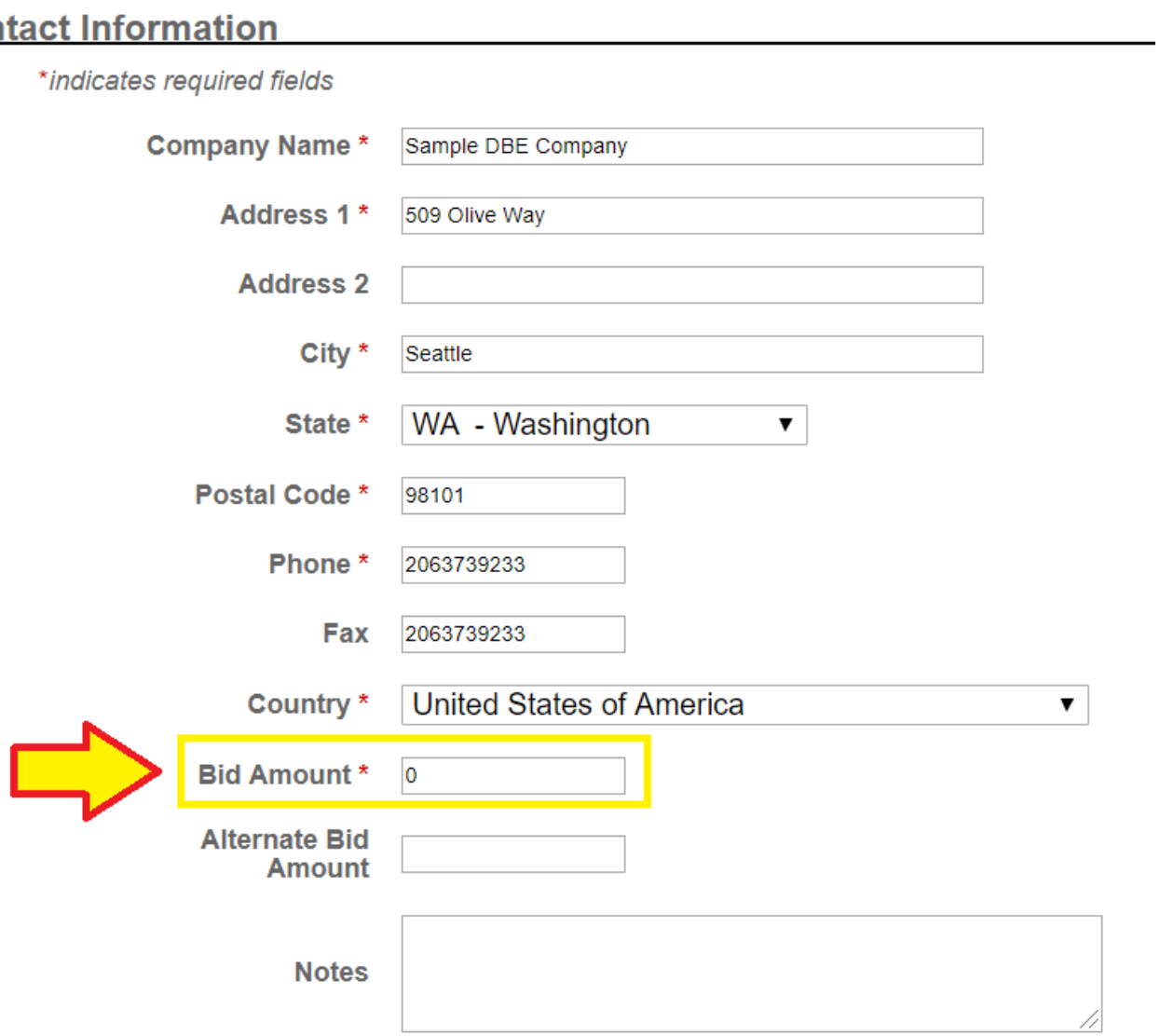


Bid Identifier	Agency Name	Bid Status	Broadcast Date	Date Due	Name	Actions
RFP-2019-01-0-2019/df	Town of Malabar	Active	5/15/2019	5/31/2019	Malabar Parks and Recreation Board Memorial Wall Project	Planholders, Download/Order, Details
EBID-20190077-0-2019/HF	City of Port St. Lucie, Procurement Management Department	Active	4/25/2019	5/31/2019	Purchase Breaching “Backpa… Gas Masks and Gas Mask Cartridges for the Police Department JAG Grant Funded	E-Bidding, Planholders, Download/Order, Details

In order to do e-bidding

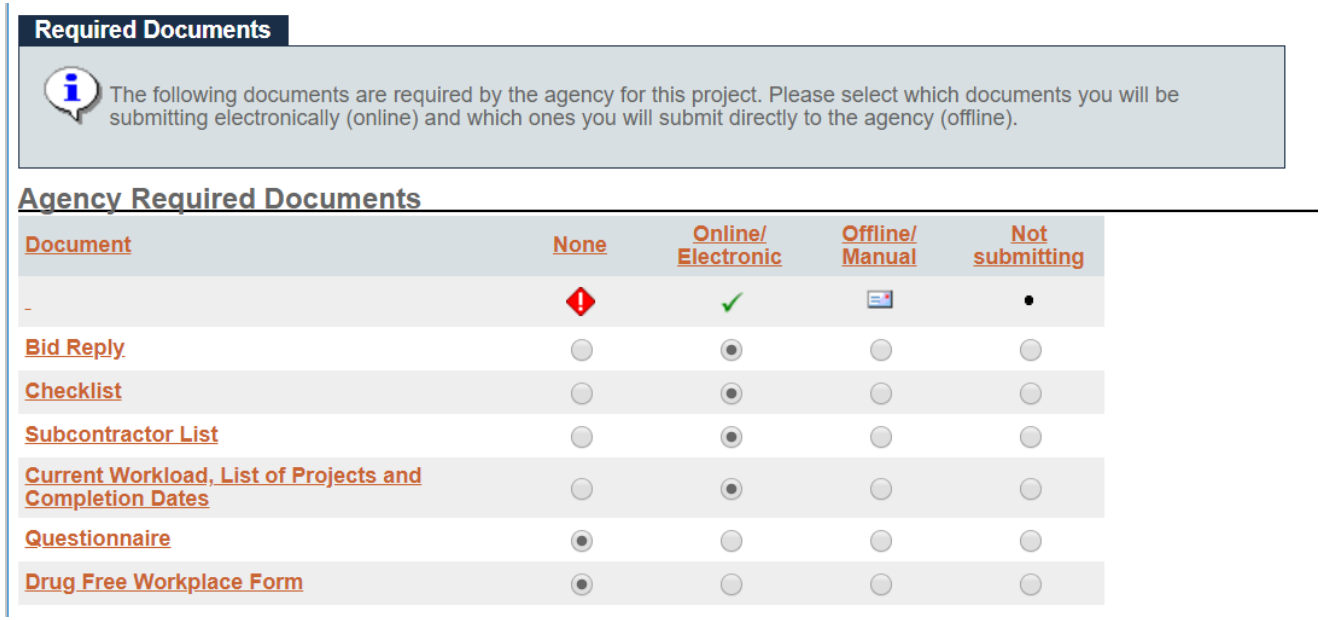
2. Enter you contact information and enter in all required fields

Note: You **MUST** put a number of the “BID AMOUNT” box. However, that number can be 0 so as to allow for a more detailed descriptions of your bid through your uploaded documents.



In order to do e-bidding

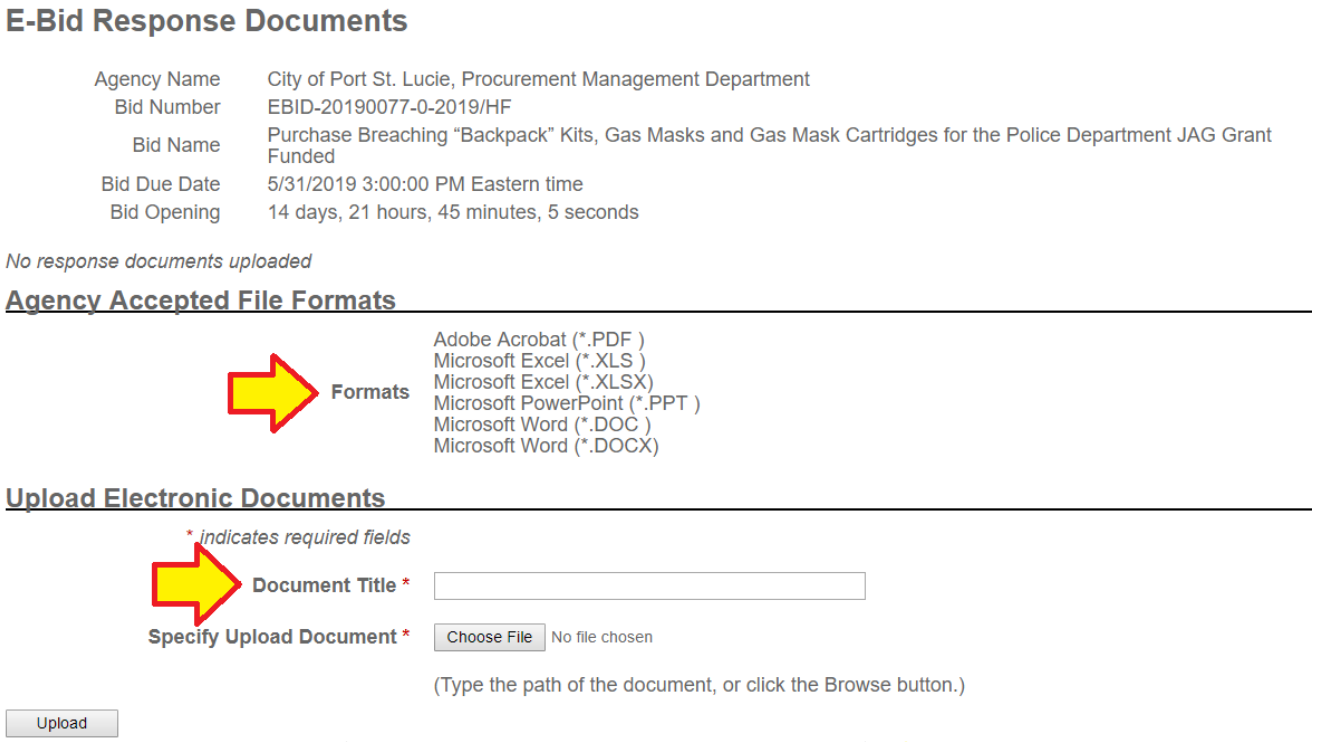
- In the agency required documents section – check the documents you intend on uploading and fulfilling. By checking these boxes this is **ONLY** an acknowledgement of how you will fulfill the requirement. You still have to upload the documents.



In order to do e-bidding

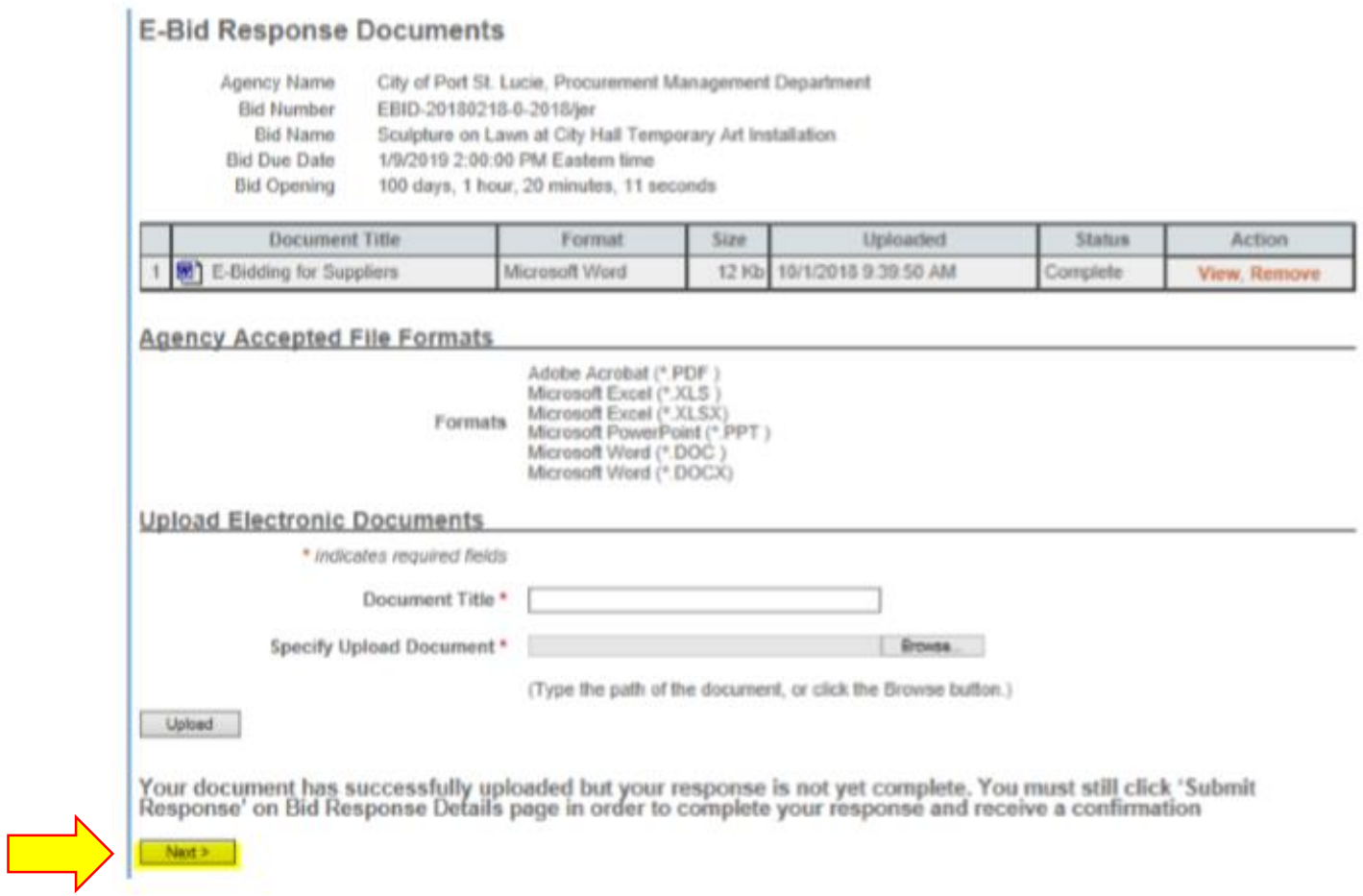
Upload your response documents in an accepted file format

Make sure that you have covered and uploaded all the required documents



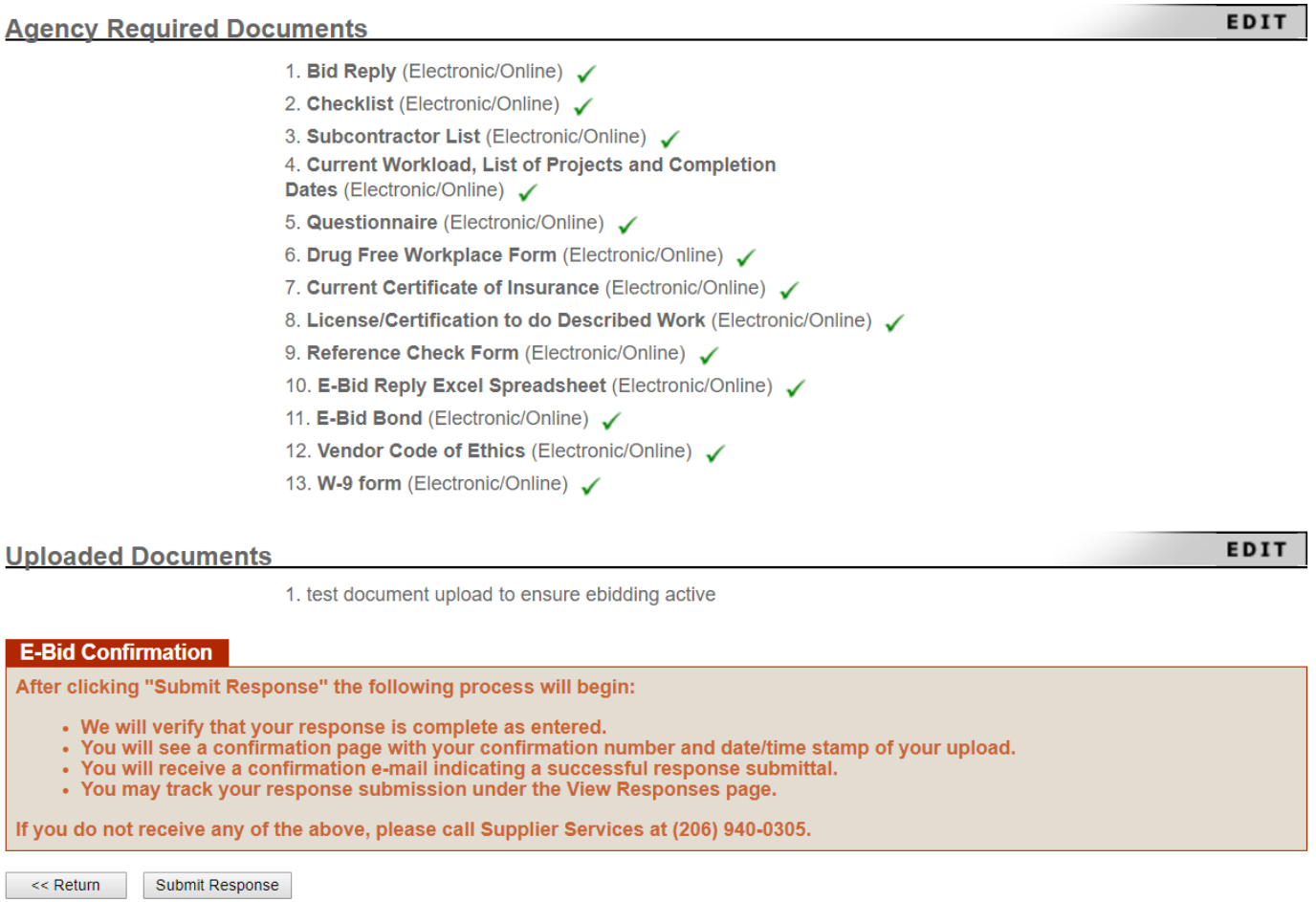
In order to do e-bidding

Once you decide you've uploaded all your documents that you would like to submit, make sure you click the **NEXT** button at the bottom of the screen



Completing your e-bid submittal

- Please **VERIFY** that you have attached **ALL** the required documents
- Click on the **Submit Response** button to complete your e-bid



Agency Required Documents EDIT

1. **Bid Reply** (Electronic/Online) ✓
2. **Checklist** (Electronic/Online) ✓
3. **Subcontractor List** (Electronic/Online) ✓
4. **Current Workload, List of Projects and Completion Dates** (Electronic/Online) ✓
5. **Questionnaire** (Electronic/Online) ✓
6. **Drug Free Workplace Form** (Electronic/Online) ✓
7. **Current Certificate of Insurance** (Electronic/Online) ✓
8. **License/Certification to do Described Work** (Electronic/Online) ✓
9. **Reference Check Form** (Electronic/Online) ✓
10. **E-Bid Reply Excel Spreadsheet** (Electronic/Online) ✓
11. **E-Bid Bond** (Electronic/Online) ✓
12. **Vendor Code of Ethics** (Electronic/Online) ✓
13. **W-9 form** (Electronic/Online) ✓

Uploaded Documents EDIT

1. test document upload to ensure ebidding active

E-Bid Confirmation

After clicking "Submit Response" the following process will begin:

- **We will verify that your response is complete as entered.**
- **You will see a confirmation page with your confirmation number and date/time stamp of your upload.**
- **You will receive a confirmation e-mail indicating a successful response submittal.**
- **You may track your response submission under the View Responses page.**

If you do not receive any of the above, please call Supplier Services at (206) 940-0305.

<< Return | Submit Response

Confirmation of Response

- When you complete you will receive a confirmation
- This is a confirmation that what you uploaded will be visible to the agency when the bid closes, **this is not** a confirmation that all your documents were fill out or submitted correctly

E-Bid Response Details

Agency Name	City of Port St. Lucie, Procurement Management Department
Bid Number	EBID-20180218-0-2018/jer
Bid Name	Sculpture on Lawn at City Hall Temporary Art Installation
Bid Due Date	1/9/2019 2:00:00 PM Eastern time
Bid Opening	100 days, 1 hour, 6 minutes, 46 seconds
Response #	15104
Results	Your bid response is submitted.

<< Return

Post Submission Edits

If you feel like you missed something or need to make a change you can go back to your submittal response and edit your e-bid. By clicking on “DETAILS” then “EDIT” the section you wish

Bid Identifier	Agency Name	Bid Status	Broadcast	Date Due ▽	Name	Status	Actions
EBID-20190077-0-2019/HF	City of Port St. Lucie, Procurement Management Department	Active	4/25/2019	5/31/2019	Purchase Breaching “Backpack” Kits, Gas Masks and Gas Mask Cartridges for the Police Department JAG Grant Funded	Incomplete	Details, Bid, History

Contact Information EDIT

Company Name	Sample DBE Company
Address 1	509 Olive Way
Address 2	
City	Seattle
State	Washington
Postal Code	98101
Phone	2063739233
Fax	2063739233
Country	United States of America
Bid Amount	$0.00
Alternate Bid Amount	
Notes	

Agency Required Documents EDIT

1. **Bid Reply** (Electronic/Online) ✓

Registering for DemandStar

DEMANDSTAR
Building Communities.

We are pleased to announce our membership in the DemandStar network. DemandStar is an online marketplace that connects our suppliers directly to the bids, quotes and RFPs that matter to them.

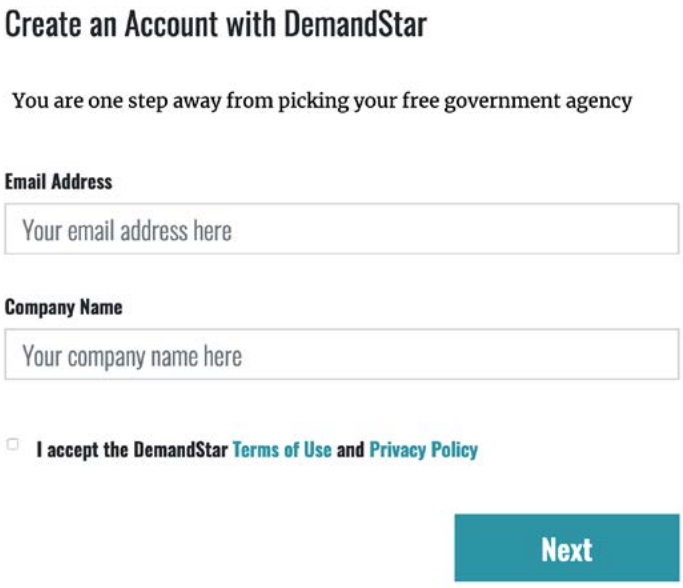
DemandStar is open and accessible to all businesses and provides instant access to our solicitations. By registering for your complimentary DemandStar account, you will receive:

- **Instant** access to bids, quotes and RFPs
- **Automatic** notifications, right to you inbox, of bids that match the commodity codes you select
- The ability to **quickly view** the contractual terms and scope of work
- All the **forms and documents** you need in one place
- Access to **more government bids** in neighboring cities, counties and states

It's EASY! Get started with these 3 easy steps!

1 REGISTER

Go to:
https://www.demandstar.com/registration



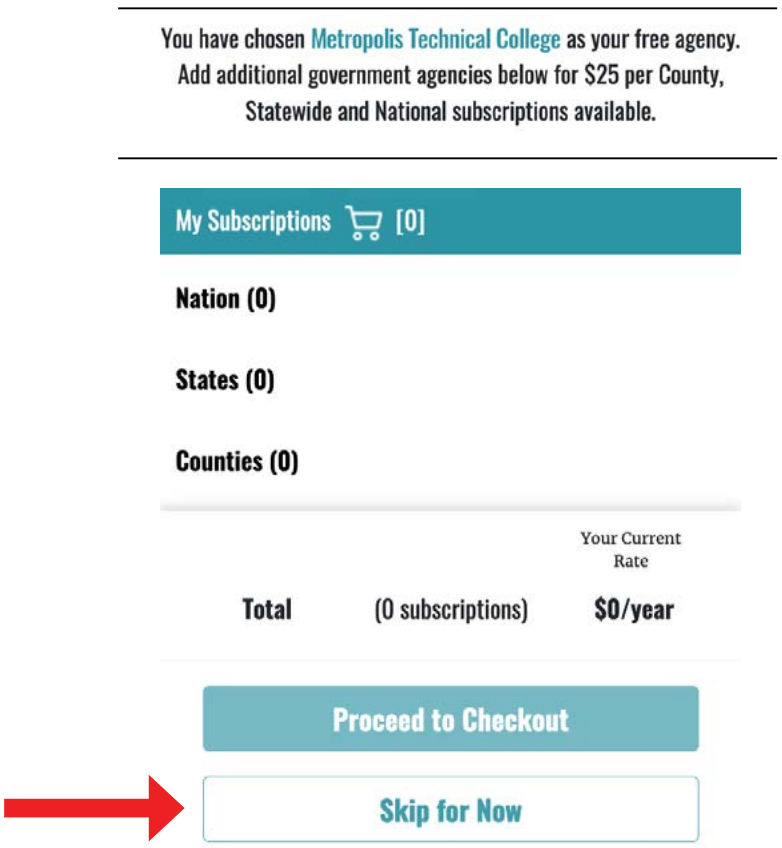
206.940.0305

2 CHOOSE YOUR FREE AGENCY

Type in the name of the government agency you'd like to add, for example "City of Metropolis" in the Search Box

3 CHECK OUT

Check out with your **FREE AGENCY** Registration by clicking "Skip for now" on the page where it gives you options to add additional counties and States



SIGN UP

Visit www.demandstar.com

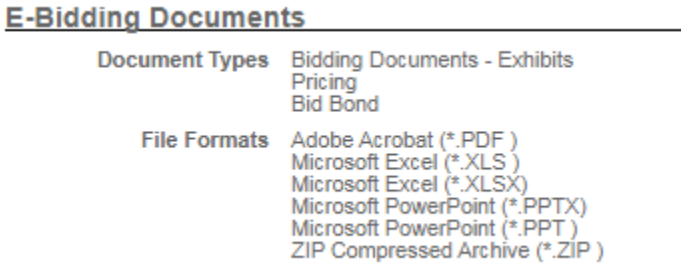
206.940.0305

DemandStar E-Bidding: Frequently Asked Questions

- Do suppliers need to be registered with DemandStar to participate in e-bidding?
  Yes. But if they don't already have an account with DemandStar, they can sign up and either
  - Be a subscriber for only your agency, at no charge, and be able to download documents at no charge and then receive notifications that match their commodity codes
  - Be a "basic supplier" for free - who researches on our platform and then pays $5 to download all documents, thus becoming a plan holder
  - Be a paid subscriber for a county, state, national and receive notifications from all included agencies

- Can suppliers respond with document uploads or do they simply fill in forms?
  Yes, they may respond with document uploads that are available to you via the DemandStar platform.

- What type of E-Bidding Documents can be uploaded?
  Acceptable file formats for sending back documents that the city will accept:



- Is there a maximum file size that I can upload?
  Vendors can simply upload a single file or multiple documents as long as it doesn't exceed 100 MBs (single or multiple files)

- After a bid opening, what document(s) are made public by DemandStar?
  None. Only the agency can see the vendor responses so you are the only ones who will determine what you want to download and make public.

- Who do I call if I have questions or problems with the DemandStar?
  The City strongly encourages each respondent to setup their account and to explore the eBidding module at least a couple of days before the bid due date.

  If you have questions or issues creating your account, accessing the eBidding module or submitting your bid prior to the bid due date, please contact DemandStar at 866.273.1863 or by email at hello@demandstar.com.