

## SECTION 31 05 19 - GEOTEXTILES

### PART 1 -- GENERAL

#### 1.1 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 (Sandpaper/Sliding Block Method)

### 1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of 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. 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 6 feet.



- E. Nominal Weight per Square Yard: 6 ounces.
- F. Physical Properties: Conform to requirements below.

PHYSICAL PROPERTY REQUIREMENTS FOR WOVEN GEOTEXTILE		
Property	Requirement	Test Method
Apparent Opening Size (AOS)	No. 40 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	0.02 sec. <sup>-1</sup> , MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	4 gpm/sq. ft, MinARV	
Wide Width Strip Tensile Strength	250 lb./in.-width, MinARV	ASTM D 4595
Wide Width Strip Elongation	15 percent, MaxARV	
Trapezoidal Tear Strength	90 lb., MinARV	ASTM D 4533
Puncture Strength	100 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:** Non-woven geotextiles shall be of the nominal weight per square yard as indicated on the Contract Drawings. Physical properties are will be unique to the weight designation of the geotextile, and are summarized in the following sections. Where no nominal weight is indicated, it shall be assumed that the 12 ounce specifications apply.

1. **Nominal Weight per square yard: 12 ounces**

<b>PHYSICAL PROPERTY REQUIREMENTS FOR NONWOVEN GEOTEXTILE (12 ounces)</b>		
<b>Property</b>	<b>Requirement</b>	<b>Test Method</b>
Apparent Opening Size (AOS)	No. 70 to No. 100 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	0.8 sec. <sup>-1</sup> , MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	65 gpm/sq. ft, MinARV	
Grab Tensile Strength	300 lb MinARV	ASTM D 4632
Elongation at Break	50 percent	ASTM D 4632
Trapezoidal Tear Strength	115 lb., MinARV	ASTM D 4533
Puncture Strength	175 lb., MinARV	ASTM D 4833
Ultraviolet Radiation Resistance	70 to 90 percent strength retention, MinARV after 500 hours	ASTM D 4355

2. **Nominal Weight per square yard: 8 ounces**

<b>PHYSICAL PROPERTY REQUIREMENTS FOR NONWOVEN GEOTEXTILE (8 ounces)</b>		
<b>Property</b>	<b>Requirement</b>	<b>Test Method</b>
Apparent Opening Size (AOS)	No. 70 to No. 100 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	1.4 sec. <sup>-1</sup> , MinARV	ASTM D 4491

Vertical Waterflow Rate	95 gpm/sq. ft, MinARV	(Falling Head)
Grab Tensile Strength	205 lb MinARV	ASTM D 4632
Elongation at Break	50 percent	ASTM D 4632
Trapezoidal Tear Strength	80 lb., MinARV	ASTM D 4533
Puncture Strength	130 lb., MinARV	ASTM D 4833
Ultraviolet Radiation Resistance	70 to 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 chain stitch, 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 sandbags 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

<b>Slope</b>	<b>Maximum Pin Spacing, feet</b>
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 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.

### 3.10 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 05 20 - GEOMEMBRANES

### PART 1 -- GENERAL

#### 1.1 SUMMARY

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

B. **Definitions:** The following definitions apply to the WORK of this Section:

1. Bridging: The condition when Geomembrane becomes suspended over its subgrade due to contraction of the material or poor installation.
2. Factory Seam: Thermal fusion welding completed at the factory by the product manufacturer.
3. Field Seam: Hot air welded, or a wedge welded seam used to bond factory-fabricated panels together in the field.
4. Fishmouth: An opening resulting from the uneven mating of two Geomembranes where the upper sheet has excessive length that prevents it from being bonded flat to the lower sheet.
5. FTMS: Federal Test Method Standard
6. Geomembrane: An essentially impermeable synthetic membrane used as a solid or liquid barrier.
7. MD: Machine Direction
8. RPP: Reinforced Polypropylene Membrane
9. Subgrade: The soil or geosynthetic surface on which the Geomembrane lies.
10. TD: Transverse Direction
11. Panel: The unit area of Geomembrane that will be seamed in the field. If the Geomembrane is not fabricated into panels in a factory, a panel is identified as a roll or portion of a roll without any seams.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The following standards are referenced in this Section:

ASTM D 413	Standard Test Methods for Rubber Property—Adhesion to Flexible Substrate
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ASTM D 751	Standard Test Methods for Coated Fabrics
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ASTM D 1149	Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment
ASTM D 1204	Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
ASTM D 2136	Standard Test Method for Coated Fabrics—Low-Temperature Bend Test
ASTM D 3083	Specification For Flexible Poly (Vinyl Chloride) Plastic Sheeting For Pond, Canal, And Reservoir Lining
ASTM D 3884	Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)
ASTM D 4885	Standard Test Method for Determining Performance Strength of Geomembranes by the Wide Strip Tensile Method
ASTM G 155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
FTMS 101C, M2031	Puncture Resistance

### 1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 - Contractor Submittals.
- B. Shop Drawings. Submit 30 days prior to deployment.
  - 1. Manufacturer material specifications and product literature.
  - 2. The fabricator shall furnish a proposed geomembrane panel layout to be approved in writing by the ENGINEER prior to material shipment. The drawings shall show: the direction of factory seams, the size of panels, the location of field seams, and the location and details of penetrations, consistent with the requirements of the project drawing. These details shall include the recommended termination details of the geomembrane.
- C. Certifications and Test Reports. Submit 30 days prior to deployment.
  - 1. Prior to installation of the panels, the fabricator shall provide the OWNER's representative with written certification that the factory seams were inspected in accordance with these specifications.
- D. Qualifications. Submit 30 days prior to deployment.
  - 1. Submit a list of at least ten facilities completed by installer. (For each installation, provide the name of facility, location, date of installation, type and thickness of geomembrane used and surface area of the installed geomembrane.)



2. Submit resumes or qualifications of the installation supervisor, master seamer and Technicians assigned to this project. The installer of the proposed RPP geomembrane shall have a minimum of one million square feet of RPP fabrication experience.
  3. Installer's Quality Control Program
  4. Manufacturers qualifications: The manufacturer of the RPP geomembrane of the type specified shall have at least five years of experience in the manufacture of RPP geomembranes. In addition, the geomembrane manufacturer shall have manufactured at least one million square feet of the specified type of geomembrane in the last five years.
- E. Warranties.
1. Submit a copy of all material warranties.
  2. Submit a copy of all liner installation warranties.
- F. Additional Submittals (Provided during and upon completion of Construction):
1. Daily written acceptance of sub-grade surface
  2. Low-temperature seaming procedures if applicable
  3. Prequalification test seam samples
  4. Field seam non-destructive test results
  5. Field seam destructive test results
  6. Daily field installation reports
  7. Installation record drawing

## **PART 2 -- PRODUCTS**

### **2.1 GEOMEMBRANE:**

- A. The geomembrane roll stock shall be manufactured by the extrusion calendaring process, consisting of first quality ingredients, suitably compounded with sufficient additives to ensure long-term durability.
- B. The finished membrane shall be uniform in color, thickness, size and surface texture. The finished membrane shall consist of two (2) plies of polypropylene laminated over one (1) ply of reinforcing scrim.
- C. The scrim shall be fully encapsulated with the encapsulation extending a minimum of 1/8" beyond the scrim edges. Exposed fabric along the length of the roll stock shall not be permitted.

D. The geomembrane material shall be 45 mil scrim-reinforced Polypropylene (RPP) with the following physical specifications:

1. Thickness: 45 mil (+/- 10%) (ASTM D751)
2. Breaking Strength:

Warp (MD)	300 lbs	(ASTM D751, Method A)
Fill (TD)	250 lbs	(ASTM D751, Method A)
3. Tear Strength:

Warp (MD)	70 lbs	(ASTM D751, Method B, mod)
Fill (TD)	70 lbs	(ASTM D751, Method B, mod)
4. Wide Width Strength:

Warp (MD)	150 lbs	(ASTM D4885)
Fill (TD)	125 lbs	(ASTM D4885)
5. Low Temperature: -40 F (ASTM D2136; 1/8" Mandrel, 4hr)
6. Dimension Stability: 1% max (ASTM D1204)
7. Hydrostatic Resistance: 350 psi (ASTM D1204)
8. Ply Adhesion: 40 lbs/in<sup>2</sup> (ASTM D751 mod)
9. Puncture Resistance: 300 lbs (FTMS 101C, Method 2031)
10. Abrasion Resistance: 7,500 cycles (ASTM D3884; H18 / 1kg)
11. Stress Crack Resistance: 3,000 hrs (ASTM D1693)
12. UV Resistance: 35,000 hrs (ASTM G154)
13. Ozone Resistance: No Cracks (ASTM D1149; 100 pphm / 14 days)

## 2.2 FACTORY SEAMS:

- A. The RPP roll stock shall be factory fabricated into the largest panels possible to minimize field seams. Field fabrication will not be allowed. Prior to factory seaming, all roll goods shall be inspected. All factory seams shall be made by thermal fusion methods. All factory seams shall have a minimum scrim-to-scrim overlap of one and one-half inches (1.5") when fabricated. Fabricated seams found to have less than the specified minimum overlap shall be repaired by adding an overlap or cap strip that provides the minimum specified overlap or it will be rejected. All seams shall be made so that thermal fusion bond extends fully along the width of the sheet so that no loose edges are present.

B. Factory Seams Shall have the Following Properties:

1. Bonded Seam Strength: 200 lb min (ASTM D751)
2. Peel Adhesion: 20 lbs/in (ASTM D413)

C. Inspection and testing of Factory Seams:

1. All sheets and seams shall be 100% visually inspected during fabrication. No defective seams or exposed scrim will be allowed. Upon discovery of any defective seam, production shall stop and the seam shall be repaired. Production personnel shall determine and rectify the cause of the defect prior to continuation of the seaming process. All exposed scrim edges shall be sealed with an approved polypropylene edge caulk, capped with a strip of polypropylene or extrusion welded. All indicated repairs shall be made before the panels are packaged for shipment.
2. In addition to visual inspection, a 48-inch weld sample shall be made with each factory seam welding unit used in this work at the beginning of every work shift and every four hours of production thereafter. Sample shall be taken from a seam specifically made for quality testing and not taken from the fabricated panel itself. Test specimens shall be cut at quarter points from each 48-inch seam sample (a total of three places) and tested for seam strength and peel adhesion. The shear seam strength shall be tested in accordance with ASTM D751 as modified in Annex A of ANSI/NSF 54. The peel adhesion shall be tested in accordance with ASTM D413 as modified in Annex A of ANSI/NSF 54.
3. A log shall be maintained showing the date, time, panel number and test results. Failure of the material and/or seams to meet all the requirements of these specifications may be cause for rejection of the material and/or seams as appropriate. Test results shall be provided to the ENGINEER upon request.

2.3 LINER BOOT

- A. Liner boots for pipes shall be fabricated to the outer dimension of the pipe and the liner slope, as indicated, and shall have the same material properties as the liner to which the boot will be attached.
- B. Liner boots shall be supplied by the same manufacturer as the liner panels, and shall be installed by a qualified liner installer, per the liner installer qualification requirements enlisted above.

2.4 PANEL PACKAGING AND STORAGE

- A. Each factory-fabricated panel shall be accordion-folded and placed onto a sturdy wooden pallet designed to be moved by a forklift or similar equipment. Each panel shall be given prominent and unique identifying markings indicating the proper direction of unfolding to facilitate layout and position in the field. The panels shall be suitably packaged, enclosed, and protected to prevent damage during shipment and each package shall be prominently marked in the same fashion as the panels within. Until needed, packaged factory fabricated panels shall be stored in their original unopened

wrapping, and protected from the direct heat of the sun, where possible. Pallets should not be stacked.

## **PART 3 -- EXECUTION**

### **3.1 SUBGRADE PREPARATION**

- A. The surfaces on which the lining is to be placed shall be maintained in a firm, clean, moist and smooth condition during the lining installation.
- B. All surfaces shall be compacted and smooth graded with anchor trenches provided as required and detailed. The subgrade shall be compacted in accordance with Section – 31 00 00 Earthwork.
- C. All surfaces to be lined shall be free of rocks, roots, gravel, grade stakes or debris that may puncture the geomembrane.
- D. An 8 oz non-woven geotextile shall be used as a cushioning agent under the RPP geomembrane.
- E. Handle products in manner that maintains undamaged condition.
- F. Do not store products directly on ground. Ship and store geotextile, if allowed, 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.
- G. All subgrade damaged by construction equipment and deemed unsuitable for geomembrane deployment shall be repaired prior to placement of the geomembrane.
- H. Immediately prior to the installation of the geomembrane, the ENGINEER and the geomembrane installer shall perform a complete and detailed inspection to determine acceptance of the finished subgrade and elevations. Any erosion or other damage to the subgrade that has occurred shall be corrected before geomembrane placement.

### **3.2 GEOMEMBRANE PLACEMENT**

- A. RPP geomembrane shall not be deployed until all applicable submittals and certifications listed in this specification are submitted and approved by the ENGINEER. Should the RPP geomembrane be deployed prior to approval of the ENGINEER, it will be at the sole risk of the geomembrane installer and/or CONTRACTOR. If the material does not meet the specification it shall be removed from the site at no cost to the OWNER.
- B. Only those panels of lining material that can be anchored and seamed together the same day shall be unpackaged and placed into position. In areas where high wind is prevalent, the lining installation should begin on the upwind side of the project and proceed downwind. The leading edge of the liner shall be secured at all times with sandbags sufficient to hold it down during high winds. The leading edges of the liner material left exposed after the day's work shall be anchored with sand bags spaced no less than 10 feet to prevent damage or displacement due to wind.

- C. The geomembrane shall be placed over the prepared surfaces in such a manner as to insure minimum handling and in accordance with the approved shop drawings. The geomembrane shall be closely fitted and sealed around all inlets, outlets, and other projections through the lining, using prefabricated pipe boots as shown in the construction details. Liner panels, damaged from any cause, shall be repaired in accordance with Section 3.3 – Field Seams.
- D. Geomembrane placement shall not be performed if subgrade or bedding moisture content prevents proper subgrade preparation, panel placement or panel seaming.
- E. The geomembrane shall not be allowed to “bridgeover” voids or low areas in the subgrade. In these areas the RPP geomembrane shall be installed with sufficient slack as to allow material to remain in intimate contact with the subgrade or the subgrade repaired.
- F. In general, field seams shall be oriented parallel to the line of the maximum slope, i.e., the seam should run down the slope. In corners and odd geometric locations, the total length of the field seam shall be minimized. If at all possible, seams shall not be located at low points in the subgrade unless geometry requires seaming to be done at these locations.
- G. No vehicles will be allowed on the geomembrane. Small rubber tired equipment with a ground pressure not exceeding 5 psi and a total weight not exceeding 750 lbs will normally be allowed. Typical equipment that is usually used during installation and testing and allowed on the geomembrane include air compressors, generators, etc. Materials, equipment, or other items shall not be dragged across the geomembrane surface or be allowed to slide down slopes on the lining. All parties walking or working on the liner shall wear soft-sole shoes. No smoking shall be permitted on the liner.

### 3.3 FIELD SEAMS

- A. A capable hot air welder or a wedge welder shall be used to seal factory-fabricated panels together in the field.
- B. Field seams shall be made as a lap joint formed by lapping the edges of the sheets four (4) to six (6) inches in accordance with the recommendations of the welder manufacturer. The contact surfaces of the sheets shall be wiped clean of all dirt, moisture, and other foreign matter. A minimum of one and one half inch (1.5”) bond shall apply to all liner field seams.
- C. Avoid fishmouths, wrinkles, folds, or pleats in the same area. Where fishmouths do occur, they should be slit out far enough from the seam to dissipate them, lapped, seamed together in the lapped area, and patched. Any necessary repairs to the RPP geomembrane shall be done using an additional piece of the specified parent material applied as stated in this specification. All patching material shall have rounded edges.
- D. Seams shall be welded only when ambient temperature is between 32°F and 110°F as measured six inches above the geomembrane surface unless the Engineer approves other limits, in writing. For temperatures below 32°F, the following procedures shall be utilized:

1. When the weather is clear and sunny with gentle winds (10 mph or less) welding can normally be performed at an ambient temperature between 32°F and 15°F (liner temperature is usually warmer than ambient due to the sun) without additional provisions other than adjusting the welding machine. Welding temperatures and machine speeds are adjusted to compensate for cloudy weather and higher winds (up to 25 mph).
2. For temperatures between 15°F and 5°F some means of preheating the liner other than that provided by the welding machine is needed. Details of the preheat (space heaters, temporary shelters, and combinations of the two) will be determined by the individual job conditions. The CONTRACTOR shall measure and record the following variables:
  - a. Liner Temperature (surface contact thermometer)
  - b. Ambient Temperature (6" above liner)
  - c. Wedge Temperature During Welding
  - d. Wedge Speed
  - e. Temperature Set Point of Wedge
3. The wedge temperature during welding must be observed and recorded. After starting a seam the temperature is observed and recorded every 20 feet for the first 60 feet or until the wedge temperature appears to have stabilized. After the temperature has stabilized the wedge temperature is observed and recorded every 15 minutes.
4. No welding can take place when it is snowing, sleeting, or raining. Snow and ice must be moved from the liner prior to welding. Snow removal is the responsibility of the general CONTRACTOR. Snow blowers are typically used to remove the top portion of snow leaving the lower 2 to 3 inches above the liner to be carefully removed by hand using plastic shovels or brooms.

### 3.4 INSPECTION AND TESTING OF FIELD SEAMS

- A. Upon completion of the liner installation, all seams shall be visually inspected for compliance with these specifications. In addition to visual inspection, all field seams shall be checked using an air lance nozzle directed on the upper edge and surface to detect any loose edges or ripples indicating unbonded areas within the seam (ASTM D 4437).
- B. All field seams shall be tightly bonded on completion of the work. Any geomembrane surface showing injury due to scuffing, penetration by foreign objects, or distress from other causes shall be replaced or repaired. All exposed scrim edges shall be sealed with an extrusion weld or capped with a strip of polypropylene.
- C. Destructive test seams are to be made by each seaming crew, at the beginning of the seaming process and every four (4) hours thereafter, or every time equipment is changed. Test seams shall be made under the same surface and environmental

conditions as the production welds (i.e., in contact with geomembrane subsurface and similar ambient temperature). These seams are to be made of like materials provided for the purpose of testing and not cut from the seamed panels. Each seaming crew and the materials they are using must be traceable and identifiable to their test seams. The samples shall be numbered, dated, and identified as to the personnel making the seam, and location made by appropriate notes on a print of the panel layout for the project. The completed field seam sample shall measure not less than 14 inches in width and 24 inches in length.

- D. The field test seams are to be tested for seam strength and peel adhesion using equipment suitable for this purpose. Seam shear strength shall be tested in accordance with ASTM 0751 (modified to use one-inch wide specimens and a test speed of 2 in/min). Peel adhesion strength shall be tested in accordance with ASTM 0413, Method A. The geomembrane installer shall provide a punch press or other suitable means for the on-site preparation of specimens for testing. The geomembrane installer shall provide a tensiometer for on-site shear and peel testing of geomembrane seams. The tensiometer shall be in good working order, built to ASTM specifications, and accompanied by evidence of recent calibration.
- E. If a test seam fails to meet the field seam design specification, then the seaming crew shall make additional test seam samples, using the same tools, equipment, environmental conditions, and seaming materials and retested.

### 3.5 PIPES AND STRUCTURE PENETRATION SEALING SYSTEM

- A. Penetrations shall be sealed using the same RPP geomembrane material, prefabricated boots, and accessories as shown on the project drawings. The prefabricated or field fabricated assembly shall be field welded to the main RPP geomembrane as shown on the project drawings so as to prevent leakage.
- B. These areas can be welded with any of the methods listed for Field Seams
- C. All sealed areas shall be air lance tested using ASTM D4437 and verified to be leak free.

### 3.6 REPAIRS

- A. Any repairs made to the liner shall be made with parent material supplied by the membrane manufacturer. Repairs shall be made with newly manufactured material. Patches shall be cut with rounded corners and shall extend a minimum of four 4 inches in each direction from the damaged area. The entire surface of the patch shall be bonded to the RPP lining material. If reinforced patches are used, the cut edges of the patch should be coated with an approved sealant or sealed with an extrusion weld.

- END OF SECTION -

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## SECTION 31 11 00 - SITE PREPARATION

### PART 1 -- GENERAL

#### 1.1 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 HATCHERY 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, broken up for use in riprap application (as they are able to meet specification 31 37 00), 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 1.5-feet 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 that are outside of the grading limits 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.

### 3.3 OVEREXCAVATION, REGRADING, AND BACKFILL UNDER FILL AREAS

- A. After the fill areas have been cleared, grubbed, and excavated, the areas to receive fill will require over-excavation, regrading, and backfill, consisting of the removal and/or stockpiling of undesirable soils. The ground surface shall be recontoured for keying the fill and removing severe or abrupt changes in the topography of the Site. The over-excavated volumes to a level 1.5-feet below the existing ground contours shall be backfilled.
- B. After removal of organic laden soil, the remaining soils that will require removal from the bedrock surface prior to the placement of embankment fill include:
  - 1. Topsoil: This soil mantles the stony clay that comprises much of the site.
  - 2. Alluvium: This material is present in the areas surrounding Fall Creek, and will be in a loose, unconsolidated condition.
  - 3. Colluvium: This material is also present on the hillsides and covers portions of the valley floor, particularly on the southern and western slopes of the site. This material will also be in a loose, unconsolidated condition.
- C. Any undesirable topsoil, alluvium, or colluvium shall be removed to the level designated by the ENGINEER and stockpiled for subsequent use as the first material to be placed in the compacted fill.
- D. Any steep, very abrupt rock faces and irregularly shaped rock outcrops of bedrock shall be regraded as directed by the ENGINEER.

- END OF SECTION -

## **SECTION 31 23 00 - CONTROLLED LOW STRENGTH MATERIAL**

### **PART 1 -- GENERAL**

#### **1.1 SUMMARY**

- A. The CONTRACTOR shall provide Controlled Low Strength Material (CLSM), complete and in place, in accordance with the Contract Documents.
- B. CLSM shall be placed where indicated and may be used, if the ENGINEER approves, for the following purposes:
  - 1. Normal CLSM with high slump, non-segregating consistency that readily flows and fills voids and difficult to reach places: pipe zone fill, trench zone fill, pipe abandonment, structure backfill, and structure cavity fill.

#### **1.2 CONTRACTOR SUBMITTALS**

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 - Contractor Submittals.
- B. Shop Drawings:
  - 1. CLSM mix designs which show the proportions and gradations of materials proposed for each type of CLSM indicated. Each mix design shall be accompanied by independent laboratory test results of the indicated properties.
  - 2. If the CONTRACTOR proposes to provide lower strength CLSM with aggregates that do not conform to ASTM C 33 - Concrete Aggregate, Shop Drawings shall include a testing program that will be used to control the variability of the aggregates. The testing program shall be acceptable to the Engineer.

#### **1.3 QUALITY CONTROL**

- A. Testing will be performed by a testing laboratory selected by the OWNER at the OWNER's expense, except as otherwise indicated.
- B. If tests of the CLSM show non-compliance with the specifications, the CONTRACTOR shall make changes as may be required to achieve compliance. Performing and paying for subsequent testing to show compliance shall be the CONTRACTOR's responsibility.
- C. Correlation Tests
  - 1. The CONTRACTOR shall perform a field correlation test for each mix of CLSM used in pipe zone, trench zone, or backfill used in amounts greater than 100-cubic yards or when CLSM is required to support traffic or other live loads on the fill less than 7 Days after placing CLSM.
  - 2. Field correlation tests shall be performed in a test pit similar in cross section to the WORK and at least 10-feet long at a location near the WORK. The proposed location shall be acceptable to the ENGINEER.

3. Laboratory and field tests shall be performed on samples taken from the same CLSM batch mix. Tests shall be performed by a laboratory at the CONTRACTOR's expense.
4. Testing shall be performed once each 2 hours during the first 8 hours, once each 8 hours during the first week, and once each 24 hours until the CLSM mix reaches the maximum design strength.
  - a. Compression testing shall be in accordance with ASTM D 4832 - Preparation and Testing of Soil-Cement Slurry Test Cylinders.
  - b. Setting test shall be in accordance with ASTM C 403 - Time of Setting of Concrete Mixtures by Penetration Resistance
  - c. Density tests shall be in accordance with ASTM C 138 - Unit Weight, Yield and Air Content (Gravimetric) of Concrete.

## **PART 2 -- PRODUCTS**

### **2.1 CONTROLLED LOW STRENGTH MATERIAL**

- A. CLSM shall be a mixture of cement, pozzolan, coarse and fine aggregate, admixtures, and water, mixed in accordance with ASTM C 94 - Ready Mixed Concrete.
- B. **Composition:** The following parameters shall be within the indicated limits and as necessary to produce the indicated compressive strengths.
  1. Mix proportions as necessary
  2. Entrained air content shall be between 0 percent minimum and 6 percent maximum.
  3. Water reducing agent content as necessary
- C. Properties
  1. Density shall be between 120 PCF minimum and 145 PCF maximum
  2. Slump shall be as required by the CONTRACTOR's methods but shall not promote segregation nor shall slump exceed 9 inches.
  3. Compressive strength at 28 Days:
    - a. Normal CLSM: Between 100 psi minimum and 300 psi maximum. Unless specifically indicated otherwise, CLSM shall be Normal CLSM.

### **2.2 CEMENT**

- A. Cement shall be Type I or II in accordance with ASTM C 150 - Portland Cement.

## 2.3 POZZOLAN

- A. Pozzolan shall be Type F or C in accordance with ASTM C 618 – Fly ash and Raw or Calcinced Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete. Pozzolan content, by weight, in Normal CLSM shall not be greater than cement content.

## 2.4 AGGREGATE

- A. Aggregate shall consist of a well graded mixture of crushed rock, soil, or sand, with a nominal maximum size of 3/8-inch. One hundred percent shall pass the 1/2-inch sieve; no more than 30 percent shall be retained on the 3/8-inch sieve; and no more than 12 percent shall pass the number 200 sieve. If more than 5 percent of the aggregate passes the number 200 sieve, the material passing the number 200 sieve shall have a plasticity index of less than 0.73 (liquid limit-20), when tested in accordance with ASTM D 4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils. Aggregate shall be free from organic matter and shall not contain more alkali, sulfates, or salts than the native materials at the Site.

## 2.5 ADMIXTURES

- A. Air entraining admixtures shall be in accordance with ASTM C 260 - Air-Entraining Admixtures for Concrete.
- B. Water reducing admixtures shall be in accordance with ASTM C 494 - Chemical Admixtures for Concrete.

## 2.6 WATER

- A. Water shall be potable, clean, and free from objectionable quantities of silt, organic matter, alkali, salt, and other impurities.

# PART 3 -- EXECUTION

## 3.1 PREPARATION

- A. Subgrade and compacted fill to receive CLSM shall be prepared according to Section 31 00 00 - Earthwork.

## 3.2 BATCHING, MIXING AND DELIVERY

- A. Batching, mixing, and delivery of CLSM shall conform to ASTM C 94. CLSM shall be mixed at a batch plant acceptable to the ENGINEER and shall be delivered in standard transit mix trucks.

## 3.3 PLACEMENT

- A. CLSM shall be placed by tailgate discharge, conveyor belts, pumped, or other means. CLSM shall be directed in place by vibrator, shovel, or rod to fill crevices and pockets. Avoid over-consolidation which causes separation of aggregate sizes.

- B. CLSM shall be continuously placed against fresh material unless otherwise approved by the ENGINEER. When new material is placed against existing CLSM, the placement area shall be free from loose and foreign material. The surface of the existing material shall be soaked a minimum of one hour before placement of fresh material, but no standing water shall be allowed when placement begins.
- C. Temperature of the CLSM shall be between 50- and 90-degrees F, when placed. CLSM shall not be placed when the air temperature is below 40 degrees F. No CLSM shall be placed against frozen subgrade or other materials having temperature less than 32 degrees F.

#### 3.4 FINISHING

- A. The finish surface shall be smooth and to the grade indicated or directed by the ENGINEER. Surfaces shall be free from fins, bulges, ridges, offsets, and honeycombing. Finishing by wood float, steel trowel, or similar methods is not required.

#### 3.5 CURING

- A. CLSM shall be kept damp for a minimum of 7 Days or until final backfill is placed.

#### 3.6 PROTECTION

- A. CLSM shall be protected from freezing for 72 hours after placement.
- B. No fill or loading shall be placed on CLSM until probe penetration resistance, as measured in accordance with ASTM C 803 - Standard Test Method for Penetration Resistance of Hardened Concrete, exceeds 650 psi.
- C. CLSM shall be protected from running water, rain, and other damage until the material has been accepted and final fill completed.

- END OF SECTION -

## **SECTION 31 23 19 - DEWATERING**

### **PART 1 -- GENERAL**

#### **1.1 SUMMARY**

- A. The CONTRACTOR shall dewater trench and structure excavations, and behind all cofferdams and protective works 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 the requirements of Section 01 33 00 – Contractor Submittals.
- B. Prior to commencement of excavation, or any work inside of the Ordinary High Water level, the CONTRACTOR shall submit a detailed plan and operation schedule for dewatering of excavations and cofferdams. 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 and cofferdams at all locations and times. The CONTRACTOR's dewatering plan is subject to review by the ENGINEER. All dewatering operations shall be adequate to assure the integrity of the finished project and shall be the responsibility of the CONTRACTOR.

#### **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. Where critical structures or facilities exist immediately adjacent to areas of proposed dewatering, reference points shall be 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 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. Likewise, the CONTRACTOR shall maintain the water level below the bottom of the cofferdam protected areas for the entire duration that the cofferdams are in place.
- 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 areas of work 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, excavations, and cofferdam protected areas 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 32 23 - SOIL STABILIZATION

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall stabilize the soil utilizing chemical grout for open-cut excavation and the application of air-placed concrete to the face of the excavation without shoring.
- B. Chemical grout shall be a relatively nonviscous solution, not a slurry, that may be injected into a permeable soil mass, undergo chemical reactions that lead to metathetical precipitation or polymerization, and result in solidification of that injected soil by binding together the soil grains for the purpose of increasing the load bearing capacity of the soil.

#### 1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 - Contractor Submittals.
- B. **Shop Drawings:** Detailed sketches of the intended injection techniques and patterns, including necessary data to prove that the chemicals contemplated will meet in all respects the requirements as to properties and qualities required by these Specifications. Any test data furnished by the CONTRACTOR substantiating the adequacy of the grout shall be from a certified testing lab.
- C. **Subcontractor Qualifications:** The CONTRACTOR shall submit satisfactory documentation that project personnel have the requisite experience and qualifications as outlined below.
- D. **Daily Data Logs:** The CONTRACTOR shall submit to the ENGINEER daily data logs of test samples for every injection batch and records of the point of injection for every batch.

#### 1.3 QUALITY CONTROL

- A. **Subcontractor Qualifications:** WORK under this Section shall be performed by a CONTRACTOR having at least 5 years of experience in the field of chemical grout soil stabilization and underpinning and having successfully completed at least 5 projects of a similar nature.

#### 1.4 WORK COORDINATION

- A. The CONTRACTOR shall fully coordinate the WORK of this Section with that of other trades involved and with the ENGINEER to ensure proper sequence, limitation, methods, and time of working so as to minimize or avoid interferences as well as performance of WORK by other trades.

## **PART 2 -- PRODUCTS**

### **2.1 MATERIALS**

- A. The solidified soil shall have an unconfined compressive strength of 50 psi at 28 days.
- B. The CONTRACTOR shall be responsible for formulation of the grout. Chemicals used shall be sodium silicate based with catalyst that will provide the required chemical grout. Water used shall be compatible with the chemical system to be used.
- C. Considering the chemistry of the gel and the conditions known at the Site, the chemical system used shall produce a stable gel. The chemical system used shall stabilize soil to permit open-cut excavation and the application of air-placed concrete to the face of the excavation without use of any shoring. The system shall have a proven record of stability.
- D. The chemicals used shall be so proportioned and mixed as to produce a chemical grout that contains no solids in suspension, may be pumped without difficulty, will penetrate and fill the voids in the soil mass, and will form a gel of the required strength and stability.
- E. Chemicals mixed into primary solutions before final batching may be stored only in accordance with the manufacturer's recommendations and must not be injected if limiting factors imposed by the manufacturer are exceeded. Any solutions not to be used for injection shall be immediately disposed of. The chemical system shall not be detrimental to the environment. The injected solution and its components shall be nontoxic.

### **2.2 SITE PREPARATION**

- A. The Site is mapped as Quaternary (Qv) and Tertiary (Tv) volcanic rock with nearby landslide deposits (Qls) associated with steep slopes on the east side of Fall Creek and just south of the Project site. Cobble- and boulder-sized rocks were observed on the ground surface at the proposed hatchery site and will likely need to be cleared to support construction. The borings advanced in the Project vicinity indicate approximately 18 inches of fill (road base) overlying slightly to completely weathered basalt. Based on the presence of sand, clay, and root structures at depth, we interpreted the deposit to be colluvium consisting of cobbles and boulders within a clay/sand matrix. Colluvium was interpreted to extend to the depths explored in boring B-13 and to a depth of 13 feet in boring B-14. Highly weathered andesite was observed below the colluvium in boring B-14 and extended to the depth explored (29 feet).
- B. Site clearing, grubbing, and removal shall be in accordance with Section 31 11 00 - Site Preparation. After preparation complete, the CONTRACTOR shall commence soil stabilization.

### **2.3 MIXING**

- A. Materials shall be accurately measured by weight or volume for mixing. If a variable proportioning pump system is used, positive controls shall be incorporated to ensure accurate proportioning. Care shall be taken not to contaminate mixing vessels with reactive chemical by spillage, splash, etc.

- B. A fast check reaction shall be made with each new primary chemical batch. A test sample shall be made of every injection batch. The CONTRACTOR shall keep records to establish the point of injection for each sample. These data shall be submitted daily to the ENGINEER.
- C. If any sample fails to show the proper gelation, the potential area of failure shall be reinjected. The CONTRACTOR shall propose methods of correction.

### **PART 3 -- EXECUTION**

#### **3.1 APPLICATION**

- A. The CONTRACTOR shall determine the extent of the soil stabilization required, subject to approval by the ENGINEER.
- B. Care shall be taken in the placing of injection points to secure accurate injection and the proper overlapping of injection cylinders.
- C. Injection rates and pressures shall be closely controlled to prevent blowout, localized "quick" conditions, and to ensure the proper filling of voids to attain the desired stabilized section.
- D. Quantities of chemical grout injected at each point shall be governed by calculated volume, backpressure, or a combination of these 2 factors. If it appears, at any point, that a large void exists, proper steps shall be taken to ensure permeation of the desired soil section.

#### **3.2 CLEANUP**

- A. Upon completion of soil stabilization, the CONTRACTOR shall dispose of all excess materials off the Site, leaving the Site clean and orderly, ready for subsequent operations.

- END OF SECTION -

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## **SECTION 31 35 00 - EROSION AND SEDIMENT CONTROL GENERAL**

### **PART 1 -- GENERAL**

#### **1.1 SUMMARY**

- A. Work includes furnishing all labor, materials and equipment required for the installation and maintenance of both permanent and temporary erosion and sediment control measures as shown on the drawings and as specified herein.
- B. Erosion and sediment control measures shall remain in place while potential for erosion exists from construction activities at the site and disposal area, during the duration of the contract and warranty period;
  - 1. Protect and stabilize soils susceptible to erosion. This includes areas where vegetative cover cannot be achieved due to soils, slopes or time of year. The contractor shall be aware of and conform to measures necessary for the control of erosion and sediment runoff according to applicable regulations.
  - 2. Prevent sediment or sediment laden water from entering all creeks and the storm drain systems or to be discharged from the construction site in accordance with the California State Water Resources Control Board, USEPA, and other applicable regulations.
- C. All temporary erosion and sediment control measures shall be installed prior to commencement of construction.

#### **1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

U.S. DEPARTMENT OF AGRICULTURE (USDA) AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

California State Water Resources Control Board, Best Management Practices for Erosion and Sediment Control

#### **1.3 CONTRACTOR SUBMITTALS**

- A. Submit Stormwater Pollution Prevention Plan (SWPPP) for acceptance in accordance with the requirements of Section 01 33 00 – Contractor Submittals and Section 01 57 20 – Temporary Environmental Controls.
  - 1. Submit SWPPP for work during construction, prepared by a registered Qualified SWPPP Developer (QSD) and signed and stamped by a registered Civil Engineer prior to the start of construction. Plan shall meet all federal, state, and local requirements.
  - 2. Submit Notice of Intent (NOI).

### **PART 2 – PRODUCTS (NOT USED)**

### **PART 3 -- EXECUTION**

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KRRC – FALL CREEK FISH HATCHERY

EROSION AND SEDIMENT CONTROL  
GENERAL  
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### 3.1 INSTALLATION

- A. Install erosion and sediment control measures per manufacturer's directions or as illustrated on the contract drawing or as identified in Section 31 35 20 – Erosion Control Barriers and Section 31 35 29 – Erosion Control Turbidity Curtain.

### 3.2 MAINTENANCE AND REMOVAL

- B. Repair and reinstall temporary soil erosion control measures as necessary to ensure proper function for the duration of ground disturbing activities and through the warranty period.
- C. Temporary erosion control devices shall be removed only after they have performed their intended function.
- D. All pipes, end sections, drainage curbs, sandbags, sediment fences and other materials which are removed from temporary erosion control devices and not incorporated into the permanent work shall become the property of the CONTRACTOR and shall be removed from the area.

- END OF SECTION -



## SECTION 31 35 20 - EROSION CONTROL BARRIER

### PART 1 -- GENERAL

#### 1.1 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 the requirements of 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 polyamide, 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, or
- B. Posts shall be steel, 1 1/2-inch, T-shaped, at least 6 feet long with protective coating.

#### 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, or
- B. Fasteners to steel posts shall be galvanized clips.

## 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 35 29 - EROSION AND SEDIMENT CONTROL TURBIDITY CURTAIN

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide instream trapping devices specifically designed to limit sediment transport impacts within a body of water. Turbidity curtains and other instream sediment trapping devices shall provide sedimentation protection for in-stream, bank, or upslope ground disturbance or from dredging or filling within a waterway.
- B. WORK shall include furnishing all labor, materials, and equipment required for the installation and maintenance of instream sediment trapping devices, complete and in place, in accordance with the Contract Documents
- C. CONTRACTOR shall be responsible for following all applicable Federal, State, and local codes and regulations, including the California State Water Resources Control Board requirements and best management practices.

#### 1.2 CONTRACTOR SUBMITTALS

- A. Submittals shall be in accordance with the requirements of Section 01 33 00 - Contractor Submittals.
- B. **Product Data:** Manufacturer's catalog sheets on turbidity curtain fabrics.

### PART 2 -- PRODUCTS

#### 2.1 FABRIC

- A. Strong heavy-weight material with ultraviolet light (UV) inhibitors.
- B. Tensile strength shall be sufficient to withstand predicted flows.
- C. Seams and line attachments shall be sewn or vulcanized welded into place.
- D. Flotation devices shall be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the curtain.

#### 2.2 ANCHORS

- A. In-stream anchors shall have a floating anchor buoy or other identifying mark.
- B. Shoreline turbidity curtain anchors shall be 2- by 4-inch or 1.33-lbs/lineal foot metal stakes.
- C. Bottom anchors shall hold the curtain in position and may be any of the following types: plow, fluke, mushroom, or a grappling hook.

## **PART 3 -- EXECUTION**

### **3.1 PREPARATION**

- A. Provide erosion control barriers at the indicated locations and as required preventing 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. For manufactured products, install per manufacturer's instructions.
- B. Install turbidity curtains parallel to flow of the watercourse.
- C. Turbidity curtain shall extend the entire depth of the watercourse.
- D. In areas heavily impacted by wind generated wave action; turbidity curtains should have slack to follow the rise and fall of the water level without submerging.
- E. Set upstream anchor points first, then unfurl the fabric, letting the flow carry the fabric to the downstream anchor points.

### **3.3 MAINTENANCE AND REMOVAL**

- A. Follow manufacturer instructions for fabric and material repair.
- B. Remove materials at low flows and in a manner to scoop and trap sediments within the fabric.
- C. Regularly inspect and repair or replace damaged components of the barrier. Unless otherwise directed, maintain the erosion control system until the disturbed area is permanently stabilized or upon final acceptance; then remove erosion and sediment control systems promptly.
- D. Dewater and dispose of sediments on the Site, if a location is indicated on the Drawings, or at an approved site arranged by the CONTRACTOR which is not in or adjacent to a stream or floodplain.

- END OF SECTION -

## SECTION 31 35 30 - EROSION AND SEDIMENT CONTROL (VEGETATIVE)

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide erosion protection including fertilizing, seeding, and mulching for all disturbed areas that are not to be paved or otherwise treated 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. Seed Mix. Submit 30 days prior to seeding activities.
  - 1. Seed mix and supplier application recommendations.
  - 2. California State Seed Law and Phytophthora-free certifications.
  - 3. Supply written guarantees offered by the seed supplier.
- C. Product Literature. Submit 30 days prior to seeding activities.
  - 1. Supply manufacturer's product literature for both the mulch material and erosion control blanket, including any recommended mix rates, application procedures, or anchorage devices and patterns.

### PART 2 -- PRODUCTS

#### 2.1 MATERIALS

- A. **Fertilizer:** Fertilizer shall be a commercial, chemical type, uniform in composition, free-flowing, conforming to state and federal laws and suitable for application with equipment designed for that purpose. Commercial fertilizer should conform to the requirements of the California Food and Agricultural Code.
- B. **Seed:** Seed shall be delivered in original unopened packages bearing an analysis of the contents. Seed shall be guaranteed 95 percent pure with a minimum germination rate of 80 percent, and shall meet California State Seed Law.
  - 1. Seed mix shall consist of brome, perennial ryegrass, barley, fescue, wheatgrass, and clover native to the Upper Klamath watershed, or some combination of two or more of the above.
  - 2. The seed mix shall conform to the final seed mix selected in the SWPPP.
  - 3. The seed mix shall have weed-free certifications and Phytophthora-free certifications.

4. Seed mix shall be fast growing species that can be established with normal rainfall and without supplemental irrigation.
  5. Seed mix shall be subject to the approval of the OWNER and ENGINEER.
- C. **Mulch:** Mulch shall be a fibrous, wood cellulose product produced for this purpose. It shall be dyed green and shall contain no growth or germination inhibiting substances and shall be manufactured so that when thoroughly mixed with seed, fertilizer, and water, in the proportions indicated it will form a homogenous slurry which is capable of being sprayed. The mulch shall be **Silva Fiber** as manufactured by **Weyerhaeuser Company**; **Conwood Fiber** as manufactured by **Consolidated Wood Conversion Corp.**; or equal.
- D. **Erosion Control Blanket:** Erosion control fabric shall be used on all slopes 4H:1V and steeper.
1. **Materials:** Erosion control fabric shall be rolled, fiber matrix between biodegradable or photodegradable polypropylene nets, and shall have a design life of 12 months or greater.
  2. **Anchorage Devices:** 6-inch biodegradable stakes from the manufacturer or staples of the proper length as recommended by the manufacturer for specific soil condition.
- E. **Manufacturers, or Equal**
1. **North American Green**

### **PART 3 -- EXECUTION**

#### **3.1 GENERAL**

- A. **Weather Conditions:** Fertilizing, seeding, or mulching operations will not be permitted when wind velocities exceed 15 miles per hour or when the ground is frozen, unduly wet, or otherwise not in a tillable condition.
- B. **Soil Preparation:** The ground to be seeded shall be graded in conformance with the Drawings and shall be loose and reasonably free of large rocks, roots, and other material which will interfere with the work.
- C. **Method of Application:** Fertilizer, seed, and mulch may be applied separately (Dry Method), or they may be mixed together with water and the homogeneous slurry applied by spraying (Hydraulic Method), except that all slopes steeper than 3 units horizontal to 1 unit vertical shall be stabilized by the Hydraulic Method.

#### **3.2 DRY METHOD**

- A. **Fertilizing:** The fertilizer shall be spread uniformly at the rate recommended by the seed supplier for the selected seed mix. The fertilizer shall be raked in and thoroughly mixed with the soil to a depth of approximately 2-inches prior to the application of seed or mulch.

- B. **Seeding:** The seed shall be broadcast uniformly at the rate of 44 lbs/acre (approximately 1 lb per 1,000 sq ft), or as recommended by the seed supplier. After the seed has been distributed it shall be incorporated into the soil by raking or by other approved methods.
- C. **Mulch Application:** Mulch shall be applied at the rate of 1,500 lb (air dried weight) per acre (approximately 1 lb per 30 sq ft).

### 3.3 HYDRAULIC METHOD

- A. The hydraulic method consists of the uniform application by spraying of a homogeneous mixture of water, seed, fertilizer, and mulch. The slurry shall be prepared by mixing the ingredients in the same proportions as indicated above. The slurry shall have the proper consistency to adhere to the earth slopes without lumping or running. Mixing time of materials shall not exceed 45 minutes from the time the seeds come into contact with the water in the mixer to the complete discharge of the slurry onto the slopes, otherwise the batch shall be recharged with seed. The mixture shall be applied using equipment containing a tank having a built-in, continuous agitation and recirculation system, and a discharge system which will allow application of the slurry to the slopes at a continuous and uniform rate. The application rates of the ingredients shall be the same as those specified for the Dry Method. The nozzle shall produce a spray that does not concentrate the slurry nor erode the soil.

### 3.4 EROSION CONTROL BLANKET

#### A. Placement

1. Biodegradable erosion control blanket shall be used on all slopes 4H:1V and steeper.
2. The erosion control shall be spread only on prepared, fertilized and seeded surfaces.
3. On all slopes, the erosion control blanket shall be laid up-and-down the slope in the direction of water flow.
4. Waste of erosion control material shall be minimized by limiting overlaps as specified and by utilizing the full length of the netting at roll ends.

#### B. Anchorage

1. Ends and sides of adjoining pieces of material shall be overlapped 6-inches and 4-inches respectively, and stapled. Six anchors shall be installed across ends. A common row of staples shall be used at side joints. Staple through both blankets, placing staples approximately 6-inches apart.
2. The top edge of the erosion control blanket shall be anchored in a 6-inch deep by 6-inch wide trench. Backfill and compact trench after stapling.
3. Anchorage shall be by means of 6-inch biodegradable stakes, or staples recommended by the manufacturer, driven vertically and full-length into the ground.

The legs shall be spread 3-inches to 4-inches apart at the ground to improve resistance to pull-out. In loose soils the use of 18-inch metal/washer pins may be required to properly anchor the blankets.

4. All slopes which are 4:1 or greater shall be stapled with 2 staples per square yard in a triangular pattern. Staples shall be installed per the manufacturer's recommended staple pattern guide.
5. The erosion control blanket shall not be stretched but should be laid loosely over the ground to avoid pulling the blanket downslope.
6. The erosion control blanket shall not be rolled out onto ground containing frost within the 6-inch penetration zone of the anchorage stakes or staples. Further, no staking or stapling shall be undertaken while any frost exists within the penetration zone.

### 3.5 WATERING

- A. Upon completion of the erosion control seeding, the entire area shall be soaked to saturation by a fine spray. The new planting shall be kept watered by a sprinkling system on the Site during dry weather or whenever necessary for proper establishment of the planting until final project acceptance. At no time shall the planting be allowed to dry out. Care shall be taken to avoid excessive washing or puddling on the surface and any such damage caused thereby shall be repaired by the CONTRACTOR.

### 3.6 MAINTENANCE PRIOR TO FINAL ACCEPTANCE

- A. The CONTRACTOR shall maintain the planted areas in a satisfactory condition until final acceptance of the project. Such maintenance shall include the filling, leveling, and repairing of any washed or eroded areas, as may be necessary, and sufficient watering to maintain the plant materials in a healthy condition. The ENGINEER may require replanting of any areas in which the establishment of the vegetative ground cover does not appear to be developing satisfactorily.

- END OF SECTION -



## SECTION 31 37 00 - RIPRAP

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide riprap, including associated earthwork, complete and in place, in accordance with the Contract Documents.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ASTM C 88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 535	Standard Test Method for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
AASHTO T 85	Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 210	Method of Test for Aggregate Durability Index.

#### 1.3 CONTRACTOR SUBMITTAL

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Testing certificates from a qualified testing agency shall be submitted prior to acceptance of the rock source to verify the conformity to the requirements of the Contract Documents.

### PART 2 -- PRODUCT

#### 2.1 STONES FOR RIPRAP

- A. Stones shall be graded in size to produce a reasonably dense mass. Riprap shall consist of dense, natural rock fragments. Stones shall be resistant to weathering and to water action; free from overburden, spoil, shale, and organic material; and shall meet the gradation requirements below. Shale and stones with shale seams are not acceptable.
- B. Riprap shall conform to the size types as follows:
1. Type I (6-inch Average Size):

Diameter	Percentage Passing
12-inch	95 - 100

6-inch	25 - 75
3-inch	0 - 10

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** – Class I Rock Slope Protection material.

2. Type II (12-inch Average Size):

<b>Diameter</b>	<b>Percentage Passing</b>
18-inch	95 - 100
12-inch	25 - 75
6-inch	0 - 5

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** – Class III Rock Slope Protection material.

3. Type III (18-inch Average Size):

<b>Diameter</b>	<b>Percentage Passing</b>
24-inch	95 - 100
18-inch	25 - 75
13-inch	0 - 5

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** – Class V Rock Slope Protection material.

4. Type IV (24-inch Average Size):

<b>Diameter</b>	<b>Percentage Passing</b>
30-inch	95 - 100
24-inch	25 - 75
18-inch	15 - 25
12-inch	0 - 5

As an alternative to the above gradation, the CONTRACTOR may use the approved State of California Department of Transportation's **CalTrans** – Class VII Rock Slope Protection material.

- C. The greatest dimension of 50 percent of the stones shall be at least two-thirds but not more than 1-1/2 times the diameter of the average size. Neither the breadth nor thickness of any piece of riprap shall be less than one-third its length. Material shall be of shapes which will form a stable protection structure of required depth. Rounded boulders or cobbles shall not be used.
- D. Stones shall consist of durable, sound, hard, angular rock meeting the following requirements for durability absorption ratio, soundness test, and abrasion test:

<b>Durability Absorption Ratio</b>	<b>Acceptability</b>
Greater than 23	Passes
10 to 23	Passes only if Durability Index is 52 or greater
Less than 10	Fails
Durability Absorption Ratio	<u>Durability Index (Coarse)</u> % absorption + 1

- E. The durability index and percent absorption shall be determined by AASHTO T 210 and AASHTO T 85, respectively. The minimum apparent specific gravity of the stones shall be 2.5 as determined by AASHTO T 85.
- F. Stones shall have less than 10 percent loss of weight after five cycles, when tested per ASTM C 88.
- G. Stones shall have a wear not greater than 40 percent, when tested per ASTM C 535.
- H. Control of gradation shall be by visual inspection. The CONTRACTOR shall furnish a sample of the proposed gradation of at least 5 tons or 10 percent of the total riprap weight, whichever is less. If approved, the sample may be incorporated into the finished riprap at a location where it can be used as a frequent reference for judging the gradation of the remainder of riprap.
- I. The acceptability of the stones will be determined by the ENGINEER prior to placement. Any difference of opinion between the ENGINEER and the CONTRACTOR shall be resolved by dumping and checking the gradation of two random truckloads of stones. Arranging for and the costs of mechanical equipment, a sorting site, and labor needed in checking gradation shall be the CONTRACTOR's responsibility.

## 2.2 GEOTEXTILE FABRIC

- A. Geotextile fabric shall conform to the requirements of Section 31 05 19 - Geotextiles.

## 2.3 FILTER MATERIAL

- A. Filter material shall be clean and free from organic matter. It shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The material shall be uniformity graded and shall conform to the following gradation:

1. Type 1

Size	Percentage Passing
3-inch	85 – 100
1-1/2 inch	45 – 75
3/4-inch	10 – 25

2. Type 2: CLASS 2, 1-1/2-inch aggregate base material, as described in Specification Section 26 of the Caltrans Standard Specifications is acceptable as Type 2 filter material.

## PART 3 -- EXECUTION

### 3.1 SURFACE PREPARATION

- A. Surfaces to receive riprap shall be smooth and firm, free of brush, trees, stumps, and other objectionable material, and shall be brought to the line and grade indicated.
- B. If a boulder is encountered during excavation of areas where large riprap is to be placed, the CONTRACTOR shall excavate around the boulder. If the boulder is larger than the largest allowable stone size for that area, the CONTRACTOR shall break up the boulder to an acceptable size or remove it entirely.
- C. Prior to placement of the geotextile, the surface shall be prepared to a smooth condition free of debris, depressions, or obstructions which may damage the geotextile. The geotextile shall be overlapped a minimum of 2-feet at longitudinal and transverse joints. Upstream sheets shall overlap downstream sheets. For slope placement, each strip shall overlap the next downhill strip. The geotextile shall be anchored using key trenches or aprons at the crest and toe of the slope. Pins may be used in securing the geotextile during installation. In no instance shall the geotextile be left exposed to sunlight longer than 7 Days. Overexposed geotextile shall be removed and replaced.

### 3.2 PLACEMENT OF FILTER BLANKET

- A. Area of riprap placement shall be excavated to the bottom of the filter blanket as indicated and in accordance with Section 31 00 00 – Earthwork. After the excavation has been completed, the top 12-inches of exposed surface shall be scarified, brought to optimum moisture content, and compacted to 95 percent of maximum density. The finished grade shall be even, self-draining, and in conformance with the slope of the finished grade.

- B. Placement of filter material shall be in accordance with Section 31 00 00. Filter material shall be placed, spread, and compacted in lifts not to exceed 12-inches.
- C. The CONTRACTOR shall remove any portion of the filter blanket that has been disturbed to the degree that the layers become mixed. Replace the removed portion with the required sizes.
- D. Filter material shall be placed as follows, unless otherwise indicated.
  - 1. For Type II, III and IV riprap, use 12-inches of Type 1 filter material.
  - 2. For Type I riprap, use 6-inches of Type 2 filter material.
- E. No filter material is required if riprap is placed directly on bedrock.

### 3.3 PLACEMENT OF RIPRAP

- A. Placement of riprap shall begin at the toe of the slope and proceed up the slope. The stones may be placed by dumping and may be spread by bulldozers or other suitable equipment as long as the underlying material is not displaced. Stones shall be placed so as to provide a minimum of voids. Smaller stones shall be uniformly distributed throughout the mass. Sufficient hand work shall be done to produce a neat and uniform surface, true to the lines, grades, and sections indicated.
- B. Where riprap is placed over a geotextile fabric, the riprap shall be placed so as to avoid damage to the geotextile. Stones shall not be dropped from a height greater than 3-feet, nor shall large stones be allowed to roll downslope.

- END OF SECTION -

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## SECTION 32 11 13 - A.C. PAVEMENT AND BASE

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide A.C. pavement and base, complete and in place, in accordance with the Contract Documents.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

##### A. Commercial Standards

AASHTO M 82	Cut-Back Asphalt (Medium Curing Type)
AASHTO M 140	Emulsified Asphalt
AASHTO M 208	Cationic Emulsified Asphalt
AASHTO M 320	Standard Specification for Performance-Graded Asphalt Binder
ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 692	Coarse Aggregate for Bituminous Paving Mixtures
ASTM D 977	Emulsified Asphalt
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1557	Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf per cu ft)
ASTM D 2027	Cutback Asphalt (Medium Curing Type)
ASTM D 2397	Cationic Emulsified Asphalt
ASTM D 2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures.
ASTM D 3515	Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.
ASTM D 6373-16	Standard Specification for Performance Graded Asphalt Binder
AI MS-2	Asphalt Mix Design Methods, 7 <sup>th</sup> Edition ( <i>Asphalt Institute</i> )

##### B. State Standards

### 1.3 CONTRACTOR SUBMITTALS

- A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals. Include job-mix formulas and other pertinent information satisfactory to the ENGINEER.
- B. **Suitability Tests of Proposed Materials:** Tests for conformance with the Specifications 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.

## PART 2 -- PRODUCTS

### 2.1 AGGREGATE BASE

- A. Materials for aggregate base shall be Type GF material in accordance with Section 31 00 00 - Earthwork.

### 2.2 PRIME COAT

- A. Prime coat shall be Type RS-2 liquid asphalt complying with the requirements of AASHTO M 82 (ASTM D 2027) and Caltrans Standard Specifications, Section 94, Asphaltic Emulsions.

### 2.3 TACK COAT

- A. Tack coat shall be emulsified asphalt Grade SS-1 or SS-1h, CSS-1 or CSS-1h diluted with one part water to one part emulsified asphalt, undiluted asphalt Grade RS-1 or CRS-1, or paving asphalt grade 64-22. Emulsified asphalt shall comply with the requirements of AASHTO M 140 (ASTM D 977) or M 208 (ASTM D 2397); paving asphalt shall comply with the requirements of AASHTO M 226 (ASTM D 3381).

### 2.4 ASPHALT CEMENT

- A. Asphalt Cement shall be Performance Grade 64-22 complying with the requirements of AASHTO M320 (ASTM D 6373-16).

### 2.5 MINERAL AGGREGATE

- A. Mineral aggregate shall be crushed stone, crushed slag, crushed gravel, stone or slag screening, sand, mineral filler, or a combination of two or more of these materials. Coarse and fine aggregates shall comply with all the quality requirements, except soundness, of ASTM D 692 and D 1073, respectively. Coarse aggregate failing to comply with abrasion requirements may be used if experience has demonstrated it to be satisfactory.



- B. Mineral filler shall comply with ASTM D 242.
- C. Combinations of aggregates having a history of polishing shall not be used in surface courses.

## 2.6 ASPHALT-AGGREGATE MIXTURE

- A. Asphalt-aggregate mix shall be Performance Grade 64-22, 1/2" maximum aggregate size Type A HMA per CalTrans specifications 39-2.02B(4)(b) and shall comply with Superpave HMA mix design, material specifications, and testing as described in MS-2 Asphalt Mix Design Methods by the *Asphalt Institute*.

## 2.7 PAVEMENT MARKING PAINT

- A. Pavement marking paint shall be a product specifically formulated for use on asphalt concrete pavement and shall have a proven record of performance and durability.

# PART 3 -- EXECUTION

## 3.1 SUBGRADE PREPARATION

- A. The subgrade shall be prepared in accordance with Section 31 00 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-in 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-in.
- 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 PAVEMENT MARKING

- A. Pavement marking paint shall be applied where indicated only when the pavement surface is dry and clean, and when the air temperature is above 40 degrees F. All equipment used in the application of pavement marking shall produce stripes and markings of uniform quality with clean and well-defined edges that conform to the details and dimensions indicated. Drips, overspray, improper markings, and paint material tracked by traffic shall be immediately removed from the pavement surface by methods previously reviewed by the ENGINEER.

- END OF SECTION -

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## SECTION 32 31 13 - CHAIN LINK FENCING AND GATES

### PART 1 -- GENERAL

#### 1.1 THE REQUIREMENT

- 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 the requirements of 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.

### 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.
- D. Fencing shall be topped with 3 lines of barbed wire on single, 45 degree supporting arms sloped outward, unless indicated otherwise on the Contract Drawings.
- E. Match Style, finish, and color of each fence component with that of other fence components.

#### 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.
- C. Height: 96 inches, unless shown otherwise.

## 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. **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.
- J. **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.
- K. **Barbed Wire Supporting Arms:** Supporting arms shall be manufacturer's standard fabrication, of metal and finish to match fence framework, with provision for anchorage to each post and attachment of three rows of barbed wire to each arm. Supporting arms may be either attached to posts or integral with post top weather cap. Supporting arm shall be single 45-degree arm type and shall be capable of withstanding 250 pounds of downward pull at outermost end.
- L. **Barbed Wire:** Barbed wire shall be 2-strand, No. 12-1/2-gauge zinc-coated steel or iron wire with four-point, 14-gauge barbs spaced no more than 5-inches apart.

## 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.
  - 3. Where barbed wire is indicated above gates, vertical members shall be extended and fabricated as required to receive barbed wire supporting arms.
- 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:
- C. **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.

- D. 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.
- E. Keeper: Keeper shall be provided which automatically engages the gate leaf and holds it in the open position until it is manually released.
- F. 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 30 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. Remove soil and debris from excavation prior to filling the hole with concrete.
  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, clasp 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 15 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.

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## SECTION 33 37 36 – HYDRODYNAMIC SEPARATORS

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide hydrodynamic separators and appurtenant WORK, complete and operable, in accordance with the Contract Documents.
- B. **Single Manufacturer:** Hydrodynamic separators and all housings, accessories, fastenings, and attachments shall be products of a single manufacturer.
- C. The manufacturer of the hydrodynamic separators shall be one that is regularly engaged in the engineering design and production of systems deployed for the treatment of storm water runoff for at least five (5) years and which have a history of successful production, acceptable to the ENGINEER.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

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

ASTM A 48	Standard Specification for Gray Iron Castings
ASTM A 185	Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 320	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A 497	Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 150	Standard Specification for Portland Cement
ASTM C 478	Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 857	Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C 858	Standard Specification for Underground Precast Concrete Utility Structures
ASTM C 990	Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

ASTM D 4097                      Standard Specification for Contact-Molded Glass-Fiber-Reinforced  
Thermoset Resin Corrosion Resistant Tanks

ASTM F 1267-01                Standard Specification for Metal, Expanded, Steel

### 1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.
- B. Shop Drawings: CONTRACTOR shall submit shop drawings of all connections to the hydrodynamic separator
- C. Manufacturer's Literature: CONTRACTOR shall submit manufacturer's literature for the product being proposed, including operation manuals, manufacturer's product plans, and any other supporting literature.
- D. Calculations: CONTRACTOR shall submit any supporting calculations used in the sizing of or selection of the hydrodynamic separator.
- E. Manufacturer's Certification: The hydrodynamic separator manufacturer shall submit to the ENGINEER a "Manufacturer's Performance Certification" certifying that each hydrodynamic separator is capable of achieving the specified removal efficiencies listed in these specifications. The certification shall be supported by independent third-party research.

### 1.4 QUALITY ASSURANCE

- A. All components shall be subject to inspection by the ENGINEER at the place of manufacture and/or installation. All components are subject to being rejected or identified for repair if the quality of materials and manufacturing do not comply with the requirements of this specification. Components which have been identified as defective may be subject for repair where final acceptance of the component is contingent on the discretion of the ENGINEER.
- B. The manufacturer shall guarantee the hydrodynamic separator components against all manufacturer originated defects in materials or workmanship for a period of twelve (12) months from the date the components are delivered to the OWNER for installation. The manufacturer shall upon its determination repair, correct, or replace any manufacturer originated defects advised in writing to the manufacturer within the referenced warranty period.

## PART 2 -- PRODUCTS

### 2.1 GENERAL REQUIREMENTS

- A. The hydrodynamic separator shall be sized to either achieve an 80 percent average annual reduction in the total suspended solid load with a particle size distribution having a mean particle size ( $D_{50}$ ) of 125 microns unless otherwise stated.
- B. The hydrodynamic separator shall be capable of capturing and retaining 100 percent of pollutants greater than or equal to 2.4 millimeters (mm) regardless of the pollutant's

specific gravity (i.e.: floatable and neutrally buoyant materials) for flows up to the devices rated treatment capacity. The device shall be designed to retain all previously captured pollutants addressed by this subsection under all flow conditions.

- C. The hydrodynamic separator shall be capable of capturing and retaining total petroleum hydrocarbons. The hydrodynamic separator shall be capable of achieving a removal efficiency of 92 and 78 percent when the device is operating at 25 and 50 percent of its rated treatment capacity, respectively. These removal efficiencies shall be based on independent third-party research for influent oil concentrations representative of storm water runoff (20 +/- 5 mg/L). The hydrodynamic separator shall be greater than 99 percent effective in controlling dry-weather accidental oil spills.
- D. The hydrodynamic separator shall be designed with a sump chamber for the storage of captured sediments and other negatively buoyant pollutants in between maintenance cycles. The minimum storage capacity provided by the sump chamber shall be in accordance with the indicated dimensions on the Contract Drawings. The boundaries of the sump chamber shall be limited to that which do not degrade the hydrodynamic separator's treatment efficiency as captured pollutants accumulate. The sump chamber shall be separate from the treatment processing portion(s) of the hydrodynamic separator to minimize the probability of fine particle re-suspension.
- E. In order to not restrict the OWNER's ability to maintain the hydrodynamic separator, the minimum dimension providing access from the ground surface to the sump chamber shall be 16 inches in diameter.
- F. The hydrodynamic separator shall convey the flow from the peak storm event of the drainage network, as defined below. If a substitute hydrodynamic separator is proposed, supporting documentation shall be submitted that demonstrates equal or better upstream hydraulic conditions compared to that specified herein. This documentation shall be signed and sealed by a Professional Engineer registered in the State of California. All costs associated with preparing and certifying this documentation shall be born solely by the CONTRACTOR.
- G. The hydrodynamic separator shall be designed to meet the California Statewide Trash Amendments Full Capture System requirements.

## 2.2 DESIGN PARAMETERS

- A. The hydrodynamic separator design shall be based on the design parameters in the following table:

Design Parameter	North Hatchery Hydrodynamic Separator (HDS1)	South Hatchery Hydrodynamic Separator (HDS2)
Trash Screening Required	Yes	Yes
Treatment Flow Rate (cfs)	0.33	0.36
Peak Flow Rate (cfs)	2.70	2.78

TSS Removal Efficiency (%)	80	80
Pipe Configuration	As indicated in plans	

## 2.3 CONCRETE STRUCTURE

- A. Housing unit of hydrodynamic separator device shall be constructed of pre-cast or cast-in-place concrete, no exceptions. Precast concrete components shall conform to applicable sections of ASTM C478, ASTM C857, and ASTM C858 and the following:
1. Concrete shall achieve a minimum 28-day compressive strength of 4,000 pounds per square-inch (psi);
  2. Unless otherwise noted, the precast concrete sections shall be designed to withstand lateral earth and AASHTO H-20 traffic loads;
  3. Cement shall be Type III Portland Cement conforming to ASTM C150;
  4. Aggregates shall conform to ASTM C33;
  5. Reinforcing steel shall be deformed billet-steel bars, welded steel wire, or deformed welded steel wire conforming to ASTM A615, A185, or A497;
  6. Joints shall be sealed with preformed joint sealing compound conforming to ASTM C990;
  7. Shipping of components shall not be initiated until a minimum compressive strength of 4,000 psi is attained or five (5) calendar days after fabrication has expired, whichever occurs first.

## 2.4 INTERNAL COMPONENTS

- A. Screen and support structure shall be manufactured of Type 316 and 316L stainless steel conforming to ASTM F1267-01;
- B. Hardware shall be manufactured of Type 316 stainless steel conforming to ASTM A320;
- C. Fiberglass components shall conform to applicable sections of ASTM D4097;

## 2.5 MANHOLE COMPONENTS

- A. Manhole castings shall be designed to withstand AASHTO H-20 loadings and manufactured of cast iron conforming to ASTM A 48 Class 30.

## 2.6 MANUFACTURERS AND MODEL, OR EQUAL

- A. **Contech Engineered Solutions, CDS 1515-3-C**



## **PART 3 -- EXECUTION**

### **3.1 STORAGE/ACCEPTANCE**

- A. The CONTRACTOR shall exercise care in the storage and handling of the hydrodynamic separator components prior to and during installation. Any repair or replacement costs associated with events occurring after delivery is accepted and unloading has commenced shall be born by the CONTRACTOR.

### **3.2 INSTALLATION**

- A. CONTRACTOR shall overexcavate 18 inches below the bottom elevation of the concrete structure, and shall backfill and compact with Type SF structural fill material in accordance with the requirements of Specification 31 00 00.
- B. The hydrodynamic separator shall be installed in accordance with the manufacturer's recommendations and related sections of the Contract Documents. The manufacturer shall provide the CONTRACTOR installation instructions and offer on-site guidance during the important stages of the installation as identified by the manufacturer at no additional expense. A minimum of 72 hours notice shall be provided to the manufacturer prior to their performance of the services included under this subsection.
- C. The CONTRACTOR shall fill all voids associated with lifting provisions provided by the manufacturer. These voids shall be filled with non-shrinking grout providing a finished surface consistent with adjacent surfaces. The CONTRACTOR shall trim all protruding lifting provisions flush with the adjacent concrete surface in a manner which leaves no sharp points or edges.
- D. The CONTRACTOR shall remove all loose material and pooling water from the hydrodynamic separator prior to the transfer of operational responsibility to the OWNER.

- END OF SECTION -

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## **SECTION 35 79 13 - TRAVELING BELT INTAKE SCREEN**

### **PART 1 -- GENERAL**

#### **1.1 SUMMARY**

- A. The CONTRACTOR shall provide traveling belt fish screens and appurtenances, electronic control system, complete and operable, in accordance with the Contract Documents.

#### **1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS**

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

##### **American Society for Testing and Materials (ASTM)**

A36/A36M      Standard Specification for Carbon Structural Steel

A240/240M      Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

##### **National Fire Protection Association (NFPA)**

70              National Electrical Code (NEC)

##### **Underwriters Laboratories, Inc. (UL)**

489              Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

508              Standard for Industrial Control Equipment

508A            Standard for Industrial Control Panels

1063            Standard for Machine-Tool Wires and Cables

#### **1.3 RELATED SECTIONS**

- A. Section 40 90 18 – Vendor Package Control Systems

#### **1.4 CONTRACTOR SUBMITTALS**

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

1. Submit schematic and elementary diagrams for control cabinet.
2. Submit power and control interconnection drawings.
3. Submit product data for programmable logic controller (PLC).

- B. Shop Drawings:

1. Complete fabrication, assembly, foundation and installation drawings, together with detailed specifications and data covering material used, power drive assembly, parts, devices and other accessories forming a part of the equipment.

2. Submit control cabinet enclosure shop drawings, showing internal and external arrangements with enumerated bill of materials detailing manufacturers and part numbers for each item.

C. Technical Manuals:

1. Submit complete technical manuals, including printed instructions for proper maintenance, lubrication, and complete parts list indicating the various parts by name, number, and exploded view where necessary.
2. A list of recommended spare parts for the OWNER to store at the facility shall be included.

## 1.5 QUALITY ASSURANCE

- A. The CONTRACTOR shall furnish the services of a trained, qualified manufacturer's representative for not less than 2 Days to assist, check, and approve the installation and start up the equipment and instruct the OWNER's operational personnel.

## PART 2 -- PRODUCTS

### 2.1 EQUIPMENT REQUIREMENTS

- A. **General:** The CONTRACTOR shall provide a vertical traveling fish screen to remove debris and protect fish. The traveling screen shall meet all applicable design criteria specified for active screen types in the National Marine Fisheries Service (NMFS) Anadromous Salmonid passage Facility Design Manual for Active screens. Debris shall be removed via spray wash at the top of the screen frame, with waste debris collected in a trough.
- B. **Construction:** The equipment shall be an automatic, self-cleaning traveling belt screen. Designs shall be such that maintenance to the mechanisms such as motors, drives, and bearings can be accomplished at the operating floor level without the use of access ladders or by dewatering the channel. The belts shall be the only moving parts to become submerged.
- C. The equipment shall be readily adaptable for installation and operation in the structure indicated. If equipment which requires a change or modification of the design indicated is submitted and accepted, the CONTRACTOR shall prepare and submit for approval drawings showing the necessary changes. Such changes shall be made at the CONTRACTOR's own expense and shall include mechanical, structural, and electrical WORK.
- D. **Capacity:** The traveling belt screens shall be designed based on the following technical criteria:

Number of screens	2
Channel width per screen, in	36
Invert Elevation, ft msl	2506.3

Platform Elevation, ft msl	2512.9
Design flow, cfs per screen	5
Maximum upstream WSL, ft msl	2511.0

- E. **Stainless Steel Bolts:** Bolts, anchor bolts, and washers which are submerged or below the top of the wall inside any hydraulic structure shall be of Type 316 stainless steel, with bronze nuts or cap screws of copper-silicon alloy, conforming to Section 05 55 00 - Miscellaneous Metalwork. Wherever stainless-steel bolts and nuts are indicated, it shall refer to the above material combination, unless specifically excluded.
- F. **Anchors:** Unless otherwise indicated, anchors shall be in accordance with Section 05 55 00 – Miscellaneous Metalwork. Submerged anchors shall be Type 316 stainless steel.
- G. The CONTRACTOR shall have the manufacturer supply the initial lubrication and necessary sealing fluids.

## 2.2 TRAVELING BELT SCREEN

- A. The Traveling Belt Screens shall consist of a 12-gauge 316 stainless steel wire screening media belt with 1" square openings, including side frames, guide rollers, cog wheels, drive components, heavy-duty hydraulic shock absorbers, and spray wash system.
- B. The Traveling Belt Screens shall be capable of supporting a maximum head differential of 3 feet across the screen.
- C. The main reduction ratio of the drive motor shall accomplish a final screen travel speed of approximately 9-10 feet per minute. Provision for screen tension adjustment shall be included. All drive components shall be designed to withstand the full NEMA stalling torque of the motor without damage to any part of the drive components.
- D. **Frames:** The traveling screen framing system shall be of mild steel construction with coating in accordance with **System 50** as described in Section 09 96 00, suitably reinforced to support loads imposed on the mechanism during operation, installation, assembly or transportation. The frame shall be securely fastened to the slot provided by the Contractor.
- E. **Debris Trough:** A debris trough shall be provided on the intake grating platform immediately behind the traveling screens to collect debris removed from the screens during operation.
- F. **Operation:** Debris shall be removed from the belt screen by a high-pressure spray wash located at the top of the frame.
- G. **Screening Discharge:** The belt shall be guided over the debris trough and the accumulated debris shall be removed by the spray wash to provide efficient cleaning of the belt.

- H. **Safety Guards and Inspection Covers:** The center portion of the front, upstream, side of the bar screen shall be protected by the gear rack support plate. Easily removable hinged wire mesh guards shall be included to cover the openings between the support plate and the side frames. The side frames and front plate shall have covered openings for easy access to the guide rollers, reducer, and pinion gear.

## 2.3 MOTORS

- A. Each motor shall be provided in accordance with Section 26 05 10 – Low-Voltage AC Electric Motors.
- B. Each motor shall be a premium efficiency, TEFC heavy-duty type, 1.15 service factor, and suitable for 480 volt, three-phase, 60 Hz supply at maximum speed. Dual voltage motors are acceptable.
- C. Each motor shall be sized to continuously carry the maximum load that develops across the full range of operation, and a minimum of 1 hp for screen motors and 1-1/2 hp for spray wash pumps, and it shall be direct connected to a gear reducer.
- D. 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.

## 2.4 CONTROL SYSTEM

- A. The control panel and all related control components shall be provided in accordance with the requirements of Sections 40 90 18 – Vendor Package Control Systems and 40 90 05 – Control Enclosures and Devices.
- B. Provide the following control system components, at a minimum:
  - 1. Provide a compact, modular microcontroller and input/output modules as required for a complete and operable system.
  - 2. Uninterruptible power supply (UPS) in the control panel that supplies a minimum of 15 minutes of backup power to the control panel during loss of power to the panel. UPS shall be sized to supply the PLC and all control logic, but not the traveling screen or spray wash pump motors.
  - 3. Surge protective devices as necessary to protect the PLC, level sensors, and other electronic devices in the control panel.
  - 4. Motor starters, motor disconnects, and motor protection inside the control panel as required, and in accordance with the applicable sections of NFPA 70.
  - 5. Indicating lights for “Power On”, “High Water Differential”, and “General Alarm”.
  - 6. Hand/Off/Auto mode selector switch.
  - 7. Emergency stop pushbutton, push-pull type.
- C. **Operational Criteria:**

1. When Hand/Off/Auto switch is in "Hand" mode, the traveling screen shall operate continuously.
2. When in "Off" mode, the traveling screen shall cease operation.
3. When in "Auto" mode, the traveling screen shall operate in accordance with the following criteria:
  - a. The traveling screen control system shall be capable of continuous automatic operation when the water differential across the screen (measured by two level sensors provided by others) exceeds the high water differential setpoint, factory set at 0.1 feet of head, until the water differential is measured to be less than the setpoint.
  - b. The traveling screen shall also operate at least once every five minutes for at least one full screen rotation (interval between operations and duration of operation shall be easily field-adjustable).
  - c. Head water differential operation shall take priority in "Auto" mode. No other operational criteria beyond the previous requirements are required.
- D. At a minimum, provide one dry, normally open contact for "General Alarm", rated 5A at 120 Vac, for remote indication. An unresolved high-water differential condition shall actuate and latch the alarm after the system senses continuous high-water differential for at least 5 minutes, adjustable.
- E. Provide two 4-20 mA analog output signals to indicate level signals remotely.
- F. **Machine Mounted Devices:** Devices, such as limit switches, photocells, and proximity switches, that are deemed necessary for machine control and product handling, shall be mounted, pre-wired, and terminated in junction boxes. Devices shall be mounted on adjustable brackets and each will be tagged with an identifying number to coincide with the electrical schematics.
- G. The PLC program shall be tested with the actual equipment by the MANUFACTURER prior to shipment, then the PLC program shall be tested again and verified at Site of installation during startup. PLC licenses and software shall transfer to the OWNER after final acceptance of the traveling screen system.

## 2.5 SPRAY WASH SYSTEM

- A. Provide a spray wash pump per traveling screen, intended for debris removal and self-cleaning.
- B. Spray wash pumps shall include foot valve and be able to lift water up to 15-ft prior to pressure boosting.
- C. The suction and discharge piping of the spray wash system shall be laid out by the CONTRACTOR in accordance with the manufacturers recommendations. Provisions shall

be provided to allow for priming of the pump suction line as required during periodic maintenance, startup, and commissioning.

- D. A special waterproof connection is required to connect motor to power cable. A manually cleaned wash water filter shall be provided similar to Yardney Model SF 6-40
- E. Refer to Section 44 35 35 for specifications on the spray pumps.

## 2.6 TOOLS AND SPARE PARTS

- A. **Tools:** The CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality hardened steel forgings with bright, finished heads and with work faces dressed to fit nuts. The set of tools shall be furnished in a labeled toolbox of suitable design provided with a hinged cover.
- B. **Spare Parts:** The CONTRACTOR shall furnish one set of spare parts for components exposed to operational wear during normal equipment service. Spare parts shall include bearings, sprockets, chains, pinions, limit switches, drive gear rack, rollers, and wiper blades.

## 2.7 MANUFACTURERS, OR EQUAL

- A. **International Water Screens (IWS)**
- B. **Hydrolox.**

## PART 3 -- EXECUTION

### 3.1 GENERAL

- A. Installation of the traveling belt screen shall be in strict accordance with the requirements of the manufacturer's written instructions and Shop Drawings.
- B. Parts of the mechanism shall be amply proportioned for stresses that may occur during fabrication, erection, and intermittent or continuous operation. Workmanship shall be of high grade and be of the latest design.

### 3.2 FIELD TESTING

- A. Upon completion of the installation, each piece of equipment and each system shall be tested for satisfactory operation without excessive noise, vibration, overheating, etc. Equipment shall be adjusted and checked for alignment, clearances, supports, and adherence to safety standards, until found satisfactory.

- END OF SECTION -



## SECTION 40 05 67 – HYDRAULIC CYLINDERS

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide a new hydraulic cylinder for raising and lowering the existing electro-anesthesia tank, complete and operable, 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 Drawing information and technical details for the cylinder shall be submitted for approval.

### PART 2 -- PRODUCTS

#### 2.1 GENERAL

- A. **Cylinder Mounting and Position Indicators:** Hydraulic cylinders shall be securely mounted by means of brackets or hardware specially designed and sized for this purpose and be of ample strength.
- B. Fasteners shall be in accordance with Section 05 55 00 - Miscellaneous Metalwork.
- C. Protective coatings shall be in accordance with Section 09 96 00 - Protective Coatings.

#### 2.2 HYDRAULIC CYLINDERS

- A. **Equipment Requirements:** The hydraulic cylinder rod shall be affixed to the existing electro-anesthesia tank frame and is intended to raise and lower the tank as required for hatchery operations.
- B. **Hydraulic Power:** The hydraulic cylinder shall be connected to the existing hydraulic pump and power source, providing hydraulic fluid at 1,000 psi at a flow rate of 2.8 gpm.
- C. **Hydraulic Fluid:** Cylinder shall use a mineral-based or petroleum-based oil with a viscosity of 18.2 centistokes to 35 centistokes at 100 degrees F at a pressure of 14 MPa (2,000 psi). The manufacturer shall submit with the Shop Drawings a statement in writing that wetted parts of the hydraulic system are suitable for extended operation with the hydraulic fluid. Hydraulic fluid with antifoam, anti-wear, rust prevention and water separating characteristics suitable for the service are desirable.
- D. **Hydraulic Cylinder**
  - 1. Construction: The hydraulic cylinder shall be double acting; of alloy steel, precision-machined, bored, and honed to a micro-finish of 0.5  $\mu$ m or better and coated against a corrosive environment. The cylinder shall be supported on a heavy steel or cast iron

base plate. The heads and piston shall be of carbon steel with Teflon wearing rings for the piston. The piston rod shall be of alloy steel with a micro-finish and hard chrome-plated, running in over-sized bronze bearings. Seals shall be Buna-N or Viton. The adaption spool shall be a single piece, flanged steel unit with an access door. Adjustable open- and closed-travel stops shall be provided.

2. Manufacturers, or equal

a. Parker Model 2.50JB3LLUxxx75.000

Piston rod diameter and end connection style shall be verified by the CONTRACTOR to match the electro-anesthesia tank lifting socket.

3. Each hydraulic cylinder shall be furnished with adjustable limit switches at fully open and fully closed positions.

4. Spare Parts and Supplies

a. Spare Parts: Furnish the following:

2 sets of packing, gaskets, O-rings, and seals

## **PART 3 -- EXECUTION**

### **3.1 INSTALLATION**

- A. Hydraulic cylinder shall be installed in accordance with the manufacturer's written instructions and as indicated on the Contract documents.

### **3.2 TESTING**

- A. CONTRACTOR shall operationally test the hydraulic cylinder during Commissioning, to be approved by the OWNER and ENGINEER
1. Operate the hydraulic cylinder in both directions at full working pressure and rated flow.
  2. Verify actuation of upper and lower limit switches at extents of required travel for electro-anesthesia tank operation.

- END OF SECTION -

## SECTION 40 23 00 - PIPING, GENERAL

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide the piping systems indicated, complete and operable, in accordance with the Contract Documents.
- B. The provisions of this Section shall apply to all piping sections.
- C. The mechanical Drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type. The mechanical Drawings are **not** pipe construction or fabrication drawings. Where pipe supports and spacing are indicated on the Drawings and are referenced to a Standard Detail, the CONTRACTOR shall use that Detail. Where pipe supports are not indicated on the Drawings, **it is the CONTRACTOR's responsibility to develop the details necessary to design and construct mechanical piping systems to accommodate the specific equipment provided, and to provide spacers, adapters, and connectors for a complete and functional system.**

#### 1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of 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. Fabrication drawings shall indicate spacers, adapters, connectors, fittings, and pipe supports to accommodate the equipment and valves in a complete and functional system.
  - 2. Thermoplastic Pipe Joints: Submit solvent cement manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.
  - 3. Gasket Material: Submit gasket manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.
  - 4. Modular Seals for Pipe: Manufacturer's catalog sheet showing materials and installation procedures.
- C. **Samples:** 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.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. **Extent of Work:** Pipes, fittings, and appurtenances shall be provided in accordance with the requirements of the applicable Sections and as indicated. Materials in contact with potable water shall be listed as compliant with NSF Standard 61.
- B. **Pipe Supports:** Pipes shall be adequately supported, restrained, and anchored in accordance with Section 40 23 02 - Pipe Supports, and as indicated. Supports shall resist stresses created by specified maximum seismic load from Project General Conditions
- C. **Lining:** Application, thickness, and curing of pipe lining shall be in accordance with the applicable Sections unless otherwise indicated.
- D. **Coating:** Application, thickness, and curing of coating on buried pipe shall be in accordance with the applicable Sections unless otherwise indicated. Pipes above ground or in structures shall be coated in accordance with Section 09 96 00 - Protective Coatings.
- E. **Pressure Rating:** Piping systems shall be designed for the maximum expected pressure as indicated on the Piping Schedule.
- F. **Inspection:** Pipe shall be subject to inspection at the place of manufacture. 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:** Except where otherwise indicated, materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards. The CONTRACTOR shall be responsible for performing material tests.
- H. **Welding Requirements:** Qualification of welding procedures used to fabricate pipe shall be in accordance with the provisions of AWS D1.1 – Structural Welding Code. Welding procedures shall be submitted for the ENGINEER's review.
- I. **Welder Qualifications:** Welding shall be done by skilled welders and welding operators who have adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of 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 piping. Machines and electrodes similar to those used in the WORK shall be used in qualification tests. Qualification testing of welders and materials used during testing is part of the WORK.

### 2.2 PIPE FLANGES

- A. **General:** Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise indicated. Attachment of the flanges to the pipe

shall conform to the applicable requirements of AWWA C207. Flange faces shall be perpendicular to the axis of the adjoining pipe. Flanges for miscellaneous small diameter pipes shall be in accordance with the standards indicated for these pipes.

B. Pressure Ratings

1. Flanges shall conform to either AWWA C207 – Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ASME B16.5 – Pipe Flanges and Flanged Fittings, 150 lb class.

C. **Blind Flanges:** Blind flanges shall be in accordance with AWWA C207, or as indicated for miscellaneous small pipes. Blind flanges for pipe sizes 12-inches and greater shall be provided with lifting eyes in the form of welded or screwed eye bolts.

D. **Flange Coating:** 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 Bolts:** Bolts and nuts shall conform to Section 05 55 00 – Miscellaneous Metalwork. All-thread studs shall be used on valve flange connections where space restrictions preclude the use of regular bolts.

F. **Insulating Flanges:** Insulated flanges shall have bolt holes 1/4-inch diameter greater than the bolt diameter.

G. **Insulating Flange Sets:** Insulating flange sets shall be provided where indicated. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers, and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inch or smaller and shall be made of acetal resin. 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. Steel washers shall be in accordance with ASTM A325 – Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength. Insulating gaskets shall be full-face.

H. Insulating flange manufacturers, or equal

1. **JM Red Devil, Type E**
2. **Maloney Pipeline Products Co.**
3. **PSI Products, Inc.**

I. Flange Gaskets

1. Gaskets for flanged joints used in general water and wastewater service shall be full-faced type, with material and thickness in accordance with AWWA C207, suitable for temperatures to 700 deg F, a pH of one to 11, and pressures to 1000 psig. Blind flanges shall have gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be permitted unless otherwise indicated. Flange gaskets shall be as manufactured by **John Crane, Style 2160, Garlock, Style 3000**, or equal.

2. Gaskets for flanged joints used in water with chloramines shall be **Gylon, Style 3500** as manufactured by **Garlock**, or equal.
3. Gaskets for flanges for PVC and CPVC piping used in general water and wastewater service shall be full faced, 1/8-inch thick, made of ethylene propylene rubber (EPR) having a Type A durometer hardness of 50 to 70 when tested in accordance with ASTM D 2240. When the mating flange has a raised face, provide a flat ring gasket filler between the PVC flange and gasket and the adjacent flange.

## 2.3 THREADED INSULATING CONNECTIONS

- A. **General:** Threaded insulating bushings, unions, or couplings, as appropriate, shall be used for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.
- B. **Materials:** Threaded insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene, or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

## 2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

- A. **General:** Cast mechanical-type couplings shall be provided where indicated. The couplings shall conform to the requirements of AWWA C606 - Grooved and Shouldered Joints. Bolts and nuts shall conform to the requirements of Section 05 50 00. Gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of grooved piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid excessive load on equipment caused by pipe movement due to steady state or transient pressure conditions, equipment connections with mechanical-type couplings shall have 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. Mechanical type couplings shall be bonded. 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. To assure uniform and compatible piping components, grooved fittings, couplings, and valves shall be furnished by the same manufacturer as the coupling. Grooving tools shall be from the same manufacturer as the grooved components.
- B. Manufacturers of ductile iron pipe couplings, or equal
  1. **Gustin-Bacon, (Aeroquip Corp.)**
  2. **Victaulic Style 31** (flexible or rigid grooving)

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

- C. Manufacturers of couplings for PVC pipe, or equal
  1. **Gustin-Bacon, (Aeroquip Corp.)**

## 2. Victaulic Style 775

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

### 2.5 SLEEVE–SPLIT TYPE COUPLINGS (**Depend-O-Lok**)

- A. **General:** Where indicated sleeve-split type couplings shall be furnished.
- B. **Construction:** Couplings shall be split-type, consisting of one or 2-piece housing, gasket assembly, bolts and nuts, and end rings. The double arch cross section that closes around the pipe ends shall be smooth to allow for expansion or contraction requirements. The pipe ends with steel end rings affixed shall provide restraint requirements. As the coupling closes, it shall confine the elastomeric gasket beneath the arches of the sleeve to create a radial seal. The axial seal shall squeeze the closure plates as the bolts pull the coupling snug around the pipe. The coupling shall permit angular pipe deflection, flexibility, contraction and expansion as designed by the manufacturer. The coupling housing shall be designed for internal pressure and external loads as determined by the design procedures of AWWA M11. The coupling shell thickness of the steel coupling shall be calculated using the formula:

$$T = P_w D_y / 2 F_s \quad \text{Where:}$$

$T$  = steel coupling thickness, in.

$D_y$  = pipe outside diameter, in.

$P_w$  = Design working pressure, psi

$F_s$  = 50 percent of minimum yield point of steel, psi

1. Coupling design calculations shall be stamped and signed by a registered engineer and shall be included in the Shop Drawing submittal for couplings.
2. The sealing members shall comprise of two "O"-ring gaskets and an elastomer sealing pad bonded to sealing plate. Internal pressure shall not be required to make the seal.

#### C. Materials

1. Unless otherwise indicated, coupling housing material shall be the same material as the piping. Carbon steel couplings shall be fabricated from ASTM A36. Stainless steel couplings shall be fabricated from ASTM A240, T-304, 304L, 316, or 316L.
2. Carbon steel end rings shall conform to ASTM A108 Grade 1018. Stainless steel end rings shall conform to ASTM A276 T-316L.
3. Bolts and nuts shall be in conformance with Section 05 50 00.
4. Gaskets shall be EPDM conforming to ASTM D2000 for air service up to 240 degrees F. Gaskets for general water or sewerage service within the temperature range of – 20 to 180 degrees F shall be isoprene or EPDM conforming to ASTM D2000.

5. Carbon steel couplings shall be fusion bond epoxy coated inside and outside of the coupling in accordance with Section 09 96 00. Couplings installed underground shall be provided with **Depend-O-Wrap** tape or equal. Application of wrapping material shall be in conformance with AWWA C209.

#### D. Pipe Preparation

1. Ends of pipes shall be prepared for the flexible split sleeve type couplings inspected and approved by the coupling manufacturer. The pipe outside diameter and roundness tolerances shall comply with tolerances listed in AWWA C219.
2. Plain ends for use with couplings shall be smooth and round for a distance of 12-inches from end of the pipe.
3. End rings shall be furnished with couplings when restraint is required. Carbon steel end rings shall be ASTM A108 Grade 1018. Stainless steel end rings shall conform to ASTM A 276 T-316L.
4. Where the split-type coupling is used to take up thermal expansion or contraction (**Depend-O-Lok F X E**) at the pipe joint, one end ring shall be fixed to one end of the pipe to keep the coupling in the proper location.
5. Where the split-type coupling is used for a fully restrained pipe joint (**Depend-O-Lok F X F**) at the pipe joint, one end ring shall be welded to each of the pipe ends to fit beneath the coupling and shall be protected by the coating. Welding design and specification shall be in conformance with the coupling manufacturer's recommendation.

#### E. Manufacturer

1. **Depend-O-Lok**

### 2.6 SLEEVE-TYPE COUPLINGS

- A. **General:** Sleeve-type couplings shall be provided where indicated. The CONTRACTOR will not be allowed to substitute a sleeve-split coupling, or any other type in lieu of sleeve coupling unless approved by the ENGINEER.
- B. **Construction:** Sleeve couplings shall be in accordance with AWWA C219 - Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe. Couplings shall be steel with steel bolts, without pipe stop. Couplings shall be of sizes to fit the pipe and fittings indicated. The middle ring shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected. 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. The coupling shall be either 5- or 7-inches long for sizes up to and including 30-inches and 10-inches long for sizes greater than 30-inches, for standard steel couplings, and 16-inches long for long-sleeve couplings. 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. The shape of the follower shall be of such design as to provide positive confinement of the gasket.



Bolts and nuts shall conform to the requirements of Section 05 50 00. Buried sleeve-type couplings shall be epoxy-coated at the factory as indicated.

- C. **Pipe Preparation:** Where indicated, the ends of the pipe shall be prepared for flexible steel couplings. Plain ends for use with couplings shall be smooth and round for a distance of 12-inches from the ends of the pipe, with outside diameter not more than 1/64-inch smaller than the nominal outside diameter of the pipe. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.
- D. **Gaskets**
1. Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," Grade 60, or equivalent suitable elastomer. The rubber in the gasket shall meet the following specifications:
    - a. Color – Jet Black
    - b. Surface – Non-blooming
    - c. Durometer Hardness – 74 plus and minus 5
    - d. Tensile Strength – 1000 psi minimum
    - e. Elongation – 175 percent minimum
  2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. Gaskets shall meet the requirements of ASTM D2000 – Classification System for Rubber Products in Automotive Applications, AA709Z, meeting Suffix B13 Grade 3, except as noted above. Where sleeve couplings are used in water containing chloramine or other fluids which attack rubber materials, gasket material shall be compatible with the piping service and fluid utilized.
  3. Gasket materials used in water with chloramines shall be **Gylon Style 3500** by **Garlock** or equal.
- E. **Piping Connection to Equipment:** Where piping connects to mechanical equipment such as pumps, compressors, and blowers, the piping shall be brought to the equipment connection aligned and perpendicular to the axis of the flange or fitting for which the piping is to be connected. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.
- F. **Insulating Sleeve Couplings:** Where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a sleeve of an insulating compound material compatible with the fluid service in order to obtain insulation of coupling metal parts from the pipe.

G. **Restrained Joints:** Sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation to prevent misalignment of the pump imparted by the thrust within the piping system.

H. Manufacturers, or equal

1. **Dresser, Style 38**

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

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

## 2.7 FLANGE COUPLING ADAPTERS

A. Flange coupling adapters shall be provided where indicated. The CONTRACTOR will not be allowed to substitute any other type in lieu of flange coupling adapter unless approved by the ENGINEER. The coupling shall be rated as indicated.

B. **Construction:** Flange coupling adapter body shall be fabricated from steel ASTM A512 – Cold-Drawn Buttweld Carbon Steel Mechanical Tubing or A513 – Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing with steel bolts, without pipe stop. Flange shall be in accordance with AWWA C207. Couplings shall be of sizes to fit the pipe and fittings indicated. The body shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected. 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. The follower flange shall be fabricated from steel, ASTM A576 – Steel Bars, Carbon, Hot Wrought, Special Quality or AISI C1012. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Flange coupling adapters installed in piping system rated for positive pressure, the coupling shall be restrained with harness bolts or tie rods. Other means of restraining the coupling such as set screws will not be acceptable. Bolts and nuts shall conform to the requirements of Section 05 50 00. Buried couplings shall be epoxy-coated at the factory as indicated.

C. **Gaskets:** Gaskets for flange coupling adapters shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," Grade 60 NSF approved, or equivalent suitable elastomer.

1. The rubber in the gasket shall meet the following specifications:

a. Color – Jet Black

b. Surface – Non-blooming

c. Durometer Hardness – 74 plus and minus 5

- d. Tensile Strength – 1000 psi Minimum
  - e. Elongation – 175 percent Minimum
- 2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. Gaskets shall meet the requirements of ASTM D2000 – Classification System for Rubber Products in Automotive Applications, AA709Z, meeting Suffix B13 Grade 3, except as noted above. Where flange coupling adapters are used in water containing chloramine or other fluids which attack rubber materials, gasket material shall be compatible with the piping service and fluid utilized.
  - 3. Gasket materials used in water with chloramines shall be **Gylon Style 3500** by **Garlock** or equal.
- D. **Piping Connection to Equipment:** Where piping connects to mechanical equipment such as pumps, compressors, and blowers, the piping shall be brought to the equipment connection aligned and perpendicular to the axis of the flange or fitting for which the piping is to be connected. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.
- E. **Restrained Joints:** Flange coupling adapters on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation to prevent misalignment of the pump imparted by the thrust within the piping system.
- F. Manufacturers, or Equal
- 1. **Smith-Blair, Model 975**
  - 2. **JCM, Model 309**
- 2.8 FLEXIBLE CONNECTORS
- A. **Low Temperatures:** Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment, and where indicated. Flexible connectors for service temperatures up to 180 deg F shall be flanged reinforced neoprene or butyl spools, rated for a working pressure of 40 to 150 psi, or reinforced flanged duck and rubber, as best suited for the application. Flexible connectors for service temperatures above 180 deg F shall be flanged, braided stainless steel spools with inner, annular, corrugated stainless steel hose, rated for minimum 150 psi working pressure, unless otherwise indicated. The connectors shall be a minimum of 9-inches long, face-to-face flanges, unless otherwise indicated. The final material selection shall be approved by the manufacturer. The CONTRACTOR shall submit Shop Drawings and calculations.
- B. **High Temperature:** Flexible connectors shall be installed in engine exhaust piping and where indicated. Connectors shall be sufficient to compensate for thermal expansion and

contraction and also to isolate vibration between the engine and the exhaust piping system. Connectors shall be stainless steel bellows type, flanged, and rated for minimum 150 psi, 2000 deg F.

## 2.9 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. This may be accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints. Expansion joints shall be flanged end, stainless steel, Monel, rubber, or other materials best suited for each individual service. The CONTRACTOR shall submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature, and pressure ratings.

## 2.10 PIPE THREADS

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

## 2.11 MODULAR MECHANICAL SEALS FOR PIPING PENETRATIONS

- A. Where indicated and where required 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. Individual links shall be constructed of EPDM rubber, be suitable for temperatures between minus 40 and plus 250 deg 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. Links shall be assembled with type 316 stainless steel bolts and nuts to form a continuous rubber belt around the pipe. Pressure plates under each bolt and nut shall be fabricated of a corrosion-resistant composite material. 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. Sizing and installation of sleeves and assemblies shall be in accordance with the manufacturer's recommendations.
- B. Manufacturers, or equal

### 1. Thunderline Corporation, Link-Seal

## PART 3 -- EXECUTION

### 3.1 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. Defective or damaged materials shall be replaced with new materials.

### 3.2 GENERAL

- A. Piping, fittings, and appurtenances shall be installed in accordance with the requirements of applicable Sections of Division 2 and Division 15. Proprietary manufactured couplings shall be installed in accordance with the coupling manufacturer's recommendation.

- B. Care shall be taken to ensure 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. Each 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. Contact surfaces for flanges, couplings, and piping ends shall be aligned parallel, concentric, and square to each axis at the piping connections.
  3. Bolts shall be initially hand-tightened with the piping connections properly aligned. Bolts shall be tightened with a torque wrench in a staggered sequence to the AISC recommended torque for the bolt material.
  4. Groove ends shall be clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove.
  5. After installation, joints shall meet the indicated leakage rate. Flanges shall not be deformed nor cracked.
- C. **Lined Piping Systems:** The lining manufacturer shall take full responsibility for the complete, final product and its application. Pipe ends and joints of lined pipes at screwed flanges shall be epoxy-coated to assure continuous protection.
- D. **Core Drilling:** Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction to avoid damage to embedded raceways and reinforcing bars.
- E. **Cleanup:** 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 handed over in a clean and functional condition.

- END OF SECTION -

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## SECTION 40 23 01 - PIPING IDENTIFICATION

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide identification for exposed piping and valves, complete and in place, in accordance with the Contract Documents.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Commercial Standards

ANSI A13.1                      Scheme for the Identification of Piping Systems

#### 1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Shop Drawings:** A list of suggested wording for each valve tag, prior to fabrication.
- C. Samples
  - 1. One sample of each type of identification device.
  - 2. Sample of each proposed color required by the pipe color schedule.

### PART 2 -- PRODUCTS

#### 2.1 IDENTIFICATION OF PIPING

- A. Except as indicated below for very short pipe lengths, identify exposed piping larger than 2-inches nominal size for the pipe contents and direction of flow.
  - 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 ANSI A13.1; color from the table below.
  - 3. Lettering: Sized per pipe size according to ANSI A13.1; color from the table below.
  - 4. Arrows: at least 2 arrows at each marker area, showing direction of flow.
- B. Pipe 2-inches and smaller shall be identified by plastic plates made from laminated 3-layer plastic with engraved black letters on white background.
- C. Pipe identification shall be as manufactured by **Brady, Seton**, or equal.

## 2.2 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 indicated system.

## 2.3 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

- A. Identifying devices for valves and the 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 plastic laminate with embossed letters. Tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to such valves or short pipes.
- C. Wording on the valve tags shall describe the exact function of each valve, e.g., "RW-SUPPLY", "WD-RETURN", etc.

## 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

- A. Conform to the following color codes.



Color Schedule				
Pipe Contents		Pipe Color	Marker Color	Letter Color
Abbreviation	Identification			
DR	Drain		green	white
FR	Fish Return		green	white
RW	Raw Water		yellow	black
UW	Utility water (non-potable water)		yellow	black
WD	Waste Drain		green	white

- END OF SECTION -

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## **SECTION 40 23 02 - PIPE SUPPORTS**

### **PART 1 -- GENERAL**

#### **1.1 SUMMARY**

- A. Provide pipe supports, hangers, guides, and anchors, complete and in place, as indicated in accordance with the Contract Documents.
- B. Where pipe support systems are not indicated on the Drawings, the CONTRACTOR shall design and provide the supports in accordance with this Section.
- C. Seismic and Wind Forces
  - 1. Pipe support details indicated in the Contract Drawings are 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.
  - 3. The CONTRACTOR shall provide additional supports as needed to resist such forces.

#### **1.2 CONTRACTOR SUBMITTALS**

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings
  - 1. Submit Shop Drawings which shall include the following information:
    - a. Drawings of pipe supports, hangers, anchors, and guides
    - b. Calculations for special supports and anchors, stamped and signed by a registered professional engineer.

### **PART 2 -- PRODUCTS**

#### **2.1 GENERAL REQUIREMENTS**

- A. Code Compliance
  - 1. Piping systems and pipe connections to equipment shall be properly anchored and supported in order to prevent undue deflection, vibration, and dislocation due to seismic events, line pressures, pipe weight, fluid weight, liquid movement, thermal changes, vibration, probable forces applied during construction, and stresses on piping, equipment, and structures.
  - 2. Supports and parts thereof shall conform to the requirements of ASME B31.1 – Power Piping, except as supplemented or modified in this Section.

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

#### B. 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 Horizontal Movements

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

#### E. Spring-Type Hangers

1. Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping.
2. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered.
3. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate the compression of the spring.

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

#### F. 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.

#### 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. Materials of Construction

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

#### I. 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.

#### J. 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 – Metal Fabrications & Miscellaneous Metals.

Pipe Support Application	Type of Concrete Anchor
New Concrete	Use embedded concrete insert anchors on a grid pattern. Use <b>Grinnell (Anvil International), Tolco</b> , or equal.

Existing Concrete	Use non-shrink grouted anchors, metallic type expansion anchors, or epoxy anchors.  Exceptions: Metallic type expansion anchors and epoxy anchors are not permitted for pipe supports subject to vibrating loads. Epoxy anchors are not permitted where the concrete temperature is in excess of 100 deg F or higher than the limiting temperature recommended by the manufacturer. Epoxy anchors are not accepted where anchors are subject to vibration or fire.
Vibratory Loads and High-Temperature Conditions	Use non-shrink grouted anchors

## 2.2 SUPPORT SPACING

- A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads.
- B. Pipe support spacing shall not exceed the maximum indicated spans.
- C. For temperatures other than ambient temperatures or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations.
- D. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of loading effects.
- E. 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

- F. Schedule 80 PVC Pipe

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

Support Spacing for Schedule 40 PVC Pipe <sup>1</sup>			
Nominal Pipe Size, inches	Maximum Support Spacing, feet, at Various Temperatures		
	60 deg F	100 deg F	140 deg F
1	5	4	NA
1-1/2	5.75	5.25	NA
2	6.5	5.75	NA
3	8	7	NA
4	9	8.5	NA
6	10	10	NA
8	13	11.75	NA
10	15	13	NA
12	13	14.5	NA
14	15	15	NA

<sup>1</sup> Reference: USACE based on Harvel Plastics Product Bulletin 112/401 (rev, 10/1/95), p. 63; spacing values based on test data developed by the manufacturer for the specific product and continuous spans; the piping is insulated and full of liquid with a specific gravity of 1.0

## 2.3 MANUFACTURED SUPPORTS

### G. 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.

### H. Manufacturers, or Equal

1. **Basic Engineers Inc.**
2. **Bergen-Paterson Pipe Support Corp.**
3. **Grinnell Corp. (Anvil International)**

4. **NPS Products, Inc.**
5. **Power Piping Company**
6. **Tolco Incorporated**

## 2.4 COATING

### I. Other Coatings

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

## **PART 3 -- EXECUTION**

### 3.1 INSTALLATION

#### J. General

1. Pipe supports, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 – Power Piping.
2. Concrete inserts for pipe hangers and supports shall be coordinated with the formwork.

#### K. Appearance

1. Pipe supports and hangers shall be positioned to produce an orderly, neat piping system.
2. Hanger rods shall be vertical, without offsets.
3. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, and without interference with other WORK.

### 3.2 FABRICATION

#### L. Quality Control

1. Pipe hangers and supports shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available.
2. Fabricated supports shall be neat in appearance without sharp corners, burrs, or edges.

- END OF SECTION -



## SECTION 40 23 15 - STEEL PIPE (ASTM A53 / A106, MODIFIED)

### 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 23 00 - Piping, General apply to the WORK of this Section.
- C. **Pipe Material Group No. 2.** The piping system defined in this section is referred to in the Pipe Schedule on Contract Sheet G-009 as Piping Material Group No. 2.

### 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 - 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. Galvanized steel pipe shall have screwed 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.
- B. 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 cast iron fittings conforming to ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.
7. Flanged steel fittings conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.
8. Grooved ductile iron fittings with grooving dimensions conforming to AWWA C 606 - Joints, Grooved and Shouldered Type.
9. Compression-type steel fittings with armored Buna S gaskets for plain end pipe.

## **PART 3 -- EXECUTION**

### **3.1 INSTALLATION**

- A. **General:** Pipes 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 pipes 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. Installation shall be free from defects.
- B. **Supports and Anchors:** Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 40 23 02 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipes shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

### **3.2 PIPE PREPARATION**

- A. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true. Ends of threaded pipes shall be reamed and filed smooth. Fittings shall be equally cleaned before assemblage.

### **3.3 PIPE JOINTS**

- A. **Threaded Joints:** Pipe threads shall conform to ASME B 1.20.1 - Pipe Threads, General Purpose (inch), and shall be full and cleanly cut with sharp dies. Not more than 3 threads shall remain exposed after installation.
- B. **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 per Section 40 23 00 - Piping, General.

- C. **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. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.
- D. **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.

### 3.4 INSPECTION AND FIELD TESTING

- A. **Inspection:** Finished installations shall be carefully inspected for proper supports, anchoring, interferences, and damage to pipe, fittings, and coating. Any damage shall be repaired.
- B. **Field Testing:** Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule for a period of not less than one hour 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.
  - 1. 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.
  - 2. After completion of the pressure tests, chlorine gas piping shall be tested for leakage using chlorine gas under operating pressures. Piping shall be thoroughly clean and dry before admitting chlorine gas into the system. Chlorine shall be slowly admitted to the piping system. Leakage shall be checked with a swab soaked in aqua ammonia solution and waved in the vicinity of each fitting. Ammonia solution shall not be applied to the fittings. Formation of white fumes will be evidence of leaks. Chlorine gas shall be purged from the line before leaks are repaired.
  - 3. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

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## SECTION 40 23 16 - STAINLESS STEEL PIPE (ASTM A312, MODIFIED)

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide stainless steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.
- B. The requirements of Section 40 23 00 - Piping, General apply to the WORK of this Section.
- C. **Pipe Material Group No. 15.** The piping system defined in this section is referred to in the Pipe Schedule on Contract Sheet G009 as Piping Material Group No. 15 (for schedule 10S pipe).

### PART 2 -- PRODUCTS

#### 2.1 PIPE MATERIAL

- A. Unless otherwise indicated, stainless steel pipe shall be in accordance with ASTM A 312 - Seamless and Welded Austenitic Stainless Steel Pipe, Type 316, seamless, Schedule 10S, with welded fittings or flanged fittings.

#### 2.2 PIPE JOINTS

- A. Stainless steel pipe shall have welded joints with socket-welding fittings, butt-welding fittings, or socket welding flanges. Stainless steel flanges shall have stainless steel bolts and nuts.

#### 2.3 FITTINGS

- A. **Socket-Welding Fittings:** Forged stainless steel fittings conforming to ASME B 16.11, Type 316.
- B. **Butt-Welding Fittings:** Wrought stainless steel butt-welding fittings conforming to ASTM A 403 - Wrought Austenitic Stainless Steel Piping Fittings, and ASME B 16.9 - Factory-Made Wrought Steel Butt-Welding Fittings, Type 316.
- C. **Flanged Fittings:** Type 316 stainless steel flanged fittings and flanges conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings.
- D. **Pressure Class:** Unless otherwise indicated, fittings shall be in accordance with the pressure classes called for in the Piping Schedule. Where not indicated, the fittings shall have the same pressure rating as the pipe.

### PART 3 -- EXECUTION

#### 3.1 INSTALLATION

- A. **General:** Stainless steel pipe 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. Installation shall be free from defects.
- B. **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.

### 3.2 PIPE PREPARATION

- A. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true. Fittings shall be equally cleaned before assembly.

### 3.3 PIPE JOINTS

- A. **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 per Section 40 23 00 - Piping, General.
  - 1. Field welding shall be minimized to the greatest extent possible by use of couplings and prefabrication of pipe systems at the factory. Pipe butt welds may be performed at the Site, providing the butt welds are performed only with an inert gas shielded process and that other indicated welding requirements are followed rigidly.
  - 2. Residue, oxide, and heat stain shall be removed from any type of field weld and the affected areas adjacent by the use of stainless steel wire brushes, followed by cleaning with an agent such as **Eutectic Company's "Euclean"** or equal, followed by complete removal of the agent.

### 3.4 INSPECTION AND FIELD TESTING

- A. **Inspection:** The finished installation shall be carefully inspected for proper supports, anchoring, interferences, and damage to pipe, fittings, and coating. Defects shall be repaired.
- B. **Field Testing:** Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1.5 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.
  - 1. 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.

2. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

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## **SECTION 40 23 19 - DUCTILE IRON PIPE (AWWA C151, MODIFIED)**

### **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**

- A. Commercial 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 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. 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 CONTROL

- 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. **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
- C. **Laying Lengths:** Nominal pipe laying lengths shall be 20-ft.
- D. **Finish:** The pipe shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.
- E. **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 shall be furnished with mechanical joints, push-on joints, flanged joints, or restrained joints as 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. 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.
- 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, in	Minimum Lining Thickness, in
3 - 12	1/16

14 - 24	3/32
30 - 64	1/8

## 2.5 EXTERIOR PROTECTION OF PIPE

- A. **Exterior Coating of Exposed Piping:** The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer conforming to the requirements of Section 09 96 00 - Protective Coatings.
- B. **Exterior Coating of Buried Piping:** The exterior coating shall be an asphaltic coating approximately 1-mil thick.
- C. **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 white.

## 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.

### 3.5 FIELD TESTING

- 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 one hour, without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1.5 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices.
- B. Leakage shall be determined by loss of pressure. Fixtures, devices, or other accessories that would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines shall be plugged or capped as appropriate during the testing procedures.
- C. Leaks shall be repaired, and the piping shall be re-tested until no leaks are found.

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## SECTION 40 23 20 - HIGH DENSITY POLYETHYLENE (HDPE) PIPE

### PART 1 -- GENERAL

#### 1.1 THE SUMMARY

- A. The CONTRACTOR shall provide high density polyethylene (HDPE) pipe, complete and in place, in accordance with this Scope of Work.
- B. **Pipe Material Group No. 31.** This piping system is referred to in the Pipe Schedule as Piping Material Group No. 31.

#### 1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

##### A. Commercial Standards

ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulation Materials
ASTM D1238	Standard Test Method for Melt Flow Rates of Thermoplastics by extrusion Plastometer
ASTM D1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D2239	Standard Specification for Polyethylene (PE) Plastic Pipe (S.I.D.R.-PR) Based on Controlled Inside Diameter
ASTM D2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM D2737	Standard Specification for Polyethylene (PE) Plastic Tubing
ASTM D2774	Standard Practice for Underground Installation of Thermoplastic Pressure Piping
ASTM D2837	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
ASTM D3035	Standard Specifications for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

ASTM D3350	Standard Specification for Polyethylene Plastic Pipe and Fittings Material
ASTM F412	Standard Terminology Relating to Plastic Piping Systems
ASTM F714	Standard Specification for Polyethylene (PE) Plastic Pipe (S.D.R.-PR) Based on Outside Diameter
ASTM F1473	Standard Test Method for Notch Tensile to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins
AWWA C906	Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 63 in., For Water Distribution and Transmission
NSF Standard 014	Plastics Piping System Components and Related Materials
NSF Standard 061	Drinking Water System Components - Health Effects

### 1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Submit shop drawings and the manufacturer's descriptive literature and certifications on all equipment listed in this specification prior to the product installations and associated fabrications.

### 1.4 WARRANTY

- A. Materials and workmanship shall have a one-year warranty to be free from defects in workmanship and materials. The warranty will be from the date of completion of construction. If deficiencies are discovered during the warranty period, the CONTRACTOR shall be required to correct these deficiencies without additional charge to the OWNER.

## PART 2 -- PRODUCTS

### 2.1 PIPE MATERIAL

- A. The HDPE pipe shall be manufactured in a plant capable of providing continuous quality control through inspection. The facility shall have the necessary testing equipment to verify that the pipe meets the requirements of AWWA C901 or C906, NSF Standard #61 and ASTM standards.
- B. Polyethylene pipe and fittings shall be made from resin meeting the requirements of the Plastic Pipe Institute as PE 3608. The resin shall meet the requirements of ASTM D3350.
- C. Pipe shall have a manufacturing standard of ASTM F-714. All fish release piping shall be DR 26, unless noted otherwise.

- D. The pipe shall contain no recycled compounds except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.
- E. HDPE shall be flexible, non-toxic and black. The pipe shall have a minimum wall thickness corresponding to the DR designation as in this Section. Pipe shall be accordance with ASTM F714.
- F. The material shall be of virgin quality.
- G. Pipe diameters shown on the drawings shall be **the nominal diameter** of pipe, following the Iron Pipe Size (IPS) convention.
- H. High-density polyethylene pipe and fittings are to be supplied by one manufacturer and meet ASTM D3350.
- I. Fish Release HDPE pipe shall be flanged with a hole pattern to connect to the outlet structure. All surfaces of the pipe that a fish may come into contact with shall be ground smooth providing fish friendly surfaces. Pipe shall be provided in lengths as designated on the drawings. CONTRACTOR shall coordinate with OWNER for transport of the pipe to the OWNER's storage area upon completion of facility start up testing.
- J. On outfall pipes that transfer fish, at all joints to other pipe materials, the interior of the HDPE pipe shall be trimmed at no more than a 45-degree angle, to smoothly match the inside diameter of the other pipe material, with no sharp edges allowed.

## 2.2 FITTINGS

- A. Butt Fusion Fittings. HDPE fittings shall be PE3408 HDPE, Cell Classification of 345464C as determined by ASTM D3350-02 and approved for AWWA use. Butt fusion fittings shall have a manufacturing standard of ASTM D3261. Molded & fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified in the plans. Fabricated fittings are to be manufactured using Data Loggers. Temperature, fusion pressure and a graphic representation of the fusion cycle shall be part of the Quality Control records. All fittings shall be suitable for use as pressure conduits, and per AWWA C906, have nominal burst values of three and one-half times the Working Pressure Rating (WPR) of the fitting.
- B. The manufacturing facility shall have the necessary testing equipment to verify that the fittings meet the requirements of AWWA C901 for sizes ½" to 2" and AWWA C906 for sizes 3" through 54".
- C. Polyethylene pipe and fittings shall be made from resin meeting the requirements of the Plastic Pipe Institute as PE 3608. The resin shall meet the requirements of ASTM D3350. High-density polyethylene pipe and fittings are to be supplied by one manufacturer.
- D. Fittings shall be the same material, thickness, and joint type as pipe to which it is connected and in accordance with ASTM D3261.

- E. All internal weld beads shall be smooth and shall protrude into the pipe no more than 1/8 inch

### **PART 3 -- EXECUTION**

#### **3.1 INSTALLATION**

- A. All pipe shall be installed in strict accordance with manufacturer's recommendations, drawings and/or specifications and in the best commercial trade practice.
- B. Pipe and fittings shall be packaged in a manner suitable for shipment by a commercial carrier. Upon receipt at Work Site, a receiving inspection shall be prepared. The quantity shall be verified, and any shipping damage shall be reported to the supplier within 7 days.
- C. Trenches shall be excavated in accordance with the plans and specifications. OSHA standards or OWNER safety policies regarding safety shall be followed regarding trench safety. If groundwater is encountered, it shall be removed by the CONTRACTOR. Shoring of the trench, where required is the responsibility of the CONTRACTOR.
- D. Flanges/MJ adapters shall be attached to pipe and fittings using butt fusion. The flanges/MJ adapters shall be aligned and centered relative to the pipe. Flanges/MJ adapters should be square with the valve or other flange before tightening of bolts. Bolts should not be used to draw flanges into alignment. Bolt threads shall be lubricated, and flat washers shall be used under flange nuts. Bolts shall be tightened using a "star tightening pattern". See manufacturer's recommendations. Twenty-four hours after first tightening the flange bolts, they must be re-tightened using the same "star tightening pattern used above. The final tightening torque shall be as indicated by the manufacturer.
- E. Wherever a pipe passes from concrete to earth, a flanged connection, mechanical seal or a flexible joint shall be installed as shown or required. Particular care shall be taken to ensure a full support of the pipe in the earth between and beyond the joints. Pipe passing through concrete wall shall have integrally cast or welded on water stop ring cast into wall.
- F. Where pipes pass through walls and floors, extreme care shall be exercised to ensure joints are watertight. HDPE wall anchors with integral seep rings shall be used at all wall connections. The pipe shall be free of all dirt and grease to secure a tight bond with the concrete.
- G. Plain end pipe and fittings shall be made using butt fusion. The butt fusion procedures shall be in accordance with the manufacturer or the PPI. The fusion equipment operator shall receive training 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. The fusion equipment shall be equipped with a Datalogger. Records of the welds (heater temperature, fusion pressure, and a graph of the fusion cycle) shall be maintained for five (5) years and supplied to the OWNER upon request.

- H. For all fish release pipes, internal beads shall be removed using a de-beading machine (de-beader) for pipes up to 20 inches in diameter (internal). Above 20 inch diameter pipes internal beads shall be removed by entering the pipe and grinding smooth.
- I. Heat Fusion Training. The supplier of the pipe and fittings shall provide a person certified by the pipe manufacturer and the fusion equipment manufacturer to train CONTRACTOR fusion equipment operators and inspectors representing the OWNER.
- J. Mechanical Joining. Polyethylene pipe and fittings shall be joined together using Flanges or Mechanical Joint (MJ) adapters. These fittings shall be made from PE 3608 HDPE, with a Cell Classification of 345464C as determined by ASTM D3350-02. Flanged and MJ adapters shall have a manufacturing standard of ASTM D3261. They shall have a pressure rating equal to the pipe unless otherwise specified on the plans.

### 3.2 INSPECTION AND FIELD TESTING

- A. Inspection: Finished installations shall be carefully inspected for proper joints and sufficient supports, anchoring, interferences, and damage to pipe, fittings, and coating. Defective Work shall be repaired.
- B. Leakage shall be determined by loss of pressure. Fixtures, devices, or other accessories that would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines shall be plugged or capped as appropriate during the testing procedures.
- C. Leaks shall be repaired, and the piping shall be re-tested until no leaks are found.

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## SECTION 40 23 22 - PVC PRESSURE PIPE

### GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide polyvinyl chloride (PVC) pressure pipe, complete and in place, in accordance with the Contract Documents.
- B. **Pipe Material Group No. 16.** This piping system is referred to in the Pipe Schedule as Piping Material Group No. 16.
- C. The requirements of Section 40 23 00 - Piping, General, apply to the WORK of this Section.
- D. This Section includes PVC pressure pipe with solvent-welded, flanged, or screwed joints.

#### 1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Shop Drawings:** The CONTRACTOR shall submit Shop Drawings of pipe, joints, bends, special fittings, and piping appurtenances.

### 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, listed as compliant with NSF Standard 61, unless otherwise indicated, in accordance with ASTM D1785 – 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 chemical in the pipe.
- B. Screwed joints that 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 PVC flanges, drilled to ASME B16.5 – Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated. Gaskets shall be ANSI 150 lb. full face, 1/8-inch thick Neoprene for water service.

#### 2.3 FITTINGS

- A. **Solvent Welded and Threaded Fittings:** Solvent-welded and threaded fittings shall be compact type, Schedule to match pipe PVC fittings in accordance with ASTM D2466 or

ASTM D2467 – Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, to match pipe schedule.

- B. **Flanged Fittings:** Flanged fittings shall be Schedule to match fabricated PVC fittings with 150 lb. flanges to ASME B16.5.

## **PART 3 -- EXECUTION**

### **3.1 INSTALLATION**

- A. **General:** PVC pipe 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. It is recommended that the CONTRACTOR obtain the assistance of the pipe manufacturer's field representative to instruct the pipefitters in the correct installation and support of PVC piping.
- B. **Supports and Anchors:** Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 40 23 02 – 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 changes.
- C. **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. Valves and flanges attached to PVC pipe shall be provided with adequate supports.

### **3.2 PIPE PREPARATION**

- A. Prior to installation, each pipe length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Ends of threaded pipes shall be reamed and filed smooth. Pipe fittings shall be equally cleaned before assembly.

### **3.3 PIPE JOINTS**

- A. **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. Pipe ends shall be inserted to the full depth of the socket.
- B. **Flange Joints:** Flanged joints shall be made with gaskets and galvanized steel bolts and nuts. Care shall be taken not to over-torque the bolts, in accordance with the manufacturer's written recommendations.



### 3.4 INSPECTION AND FIELD TESTING

- A. **Inspection:** Finished installations shall be carefully inspected for proper joints and sufficient supports, anchoring, interferences, and damage to pipe, fittings, and coating. Defective WORK shall be repaired.
- B. **Field Testing:** The CONTRACTOR shall allow adequate time for the solvent cement joints to cure. Curing time shall be per the solvent cement manufacturer's recommendation. Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour, without exceeding the tolerances listed in the Piping Schedule. Caution – Do not use air or gas for testing PVC pipe. Where no pressures are indicated, the pipes shall be subject to 1.5 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices.
- C. Leakage shall be determined by loss of pressure. Fixtures, devices, or other accessories that would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines shall be plugged or capped as appropriate during the testing procedures.
- D. Leaks shall be repaired, and the piping shall be re-tested until no leaks are found.

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## SECTION 40 90 00 - PROCESS INSTRUMENTATION AND CONTROL, GENERAL

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide a Supervisory Control and Data Acquisition (SCADA) system complete and operable, in accordance with the Contract Documents.
- B. The requirements of this section apply to every component of the SCADA system unless indicated otherwise.
- C. **Responsibilities:**
  - 1. The CONTRACTOR, through the use of an Instrumentation Supplier and qualified electrical and mechanical installers, shall be responsible for the implementation of the SCADA system and the integration of the SCADA system with other required instrumentation and control devices.
  - 2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the Instrumentation Supplier be responsible to the CONTRACTOR for the integration of the SCADA system with devices provided under other sections with the objective of providing a completely integrated control system fully functional and free of signal incompatibilities.
  - 3. As a minimum, the Instrumentation Supplier shall perform the following WORK:
    - a. Implementation of the SCADA system:
      - 1) Prepare all 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) Conduct the performance test.

- 12) Prepare Technical Manuals.
- 13) Conduct training classes.
- 14) Prepare record drawings.
- b. Integration of the SCADA system with instrumentation and control devices provided under other sections:
  - 1) Develop requisite loop drawings and record loop drawings associated with equipment provided under other divisions of these specifications and OWNER-furnished equipment.
  - 2) Resolve signal, power, or functional incompatibilities between the SCADA system and interfacing devices.
- 4. 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 Instrumentation Supplier if the CONTRACTOR and Instrumentation Supplier so agree.
- D. All process instrumentation is listed in the Instrumentation Schedule under Part 4 – Appendix A of Section 40 90 10 – Instrumentation for Process Systems.
- E. All process control data points (input/output points) (I/O points) are listed in the PLC I/O Schedule under Part 4 – Appendix A of this section.

## 1.2 RELATED SECTIONS

- A. Section 40 90 05 – Control Enclosures and Devices
- B. Section 40 90 10 – Instrumentation for Process Systems
- C. Section 40 90 18 – Vendor Package Control Systems

## 1.3 REFERENCE STANDARDS

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

### **Instrument Society of America Standard (ISA)**

- 5.1 Instrumentation Symbols and Identification
- 5.4 Instrument Loop Drawings
- 20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

### **National Fire Protection Agency (NFPA)**

- 70 National Electrical Code

**Underwriters Laboratories, Inc. (UL)**

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Industrial Control Equipment

**1.4 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 OWNER'S REPRESENTATIVE 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 OWNER'S REPRESENTATIVE, 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 OWNER'S REPRESENTATIVE 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. Symbolology and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbolology as derived from ISA 5.1. 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. Shop Drawings:**

**1. General:**

- a. Shop drawings shall include the letter head or title block of the Instrumentation Supplier. The title block shall include, at 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.
- b. 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.
- c. Shop drawing information shall be bound in standard size, 3-ring, loose-leaf, vinyl plastic, and hard cover binders suitable for bookshelf storage.

- d. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders, and other equipment related to the SCADA system shall be included in the shop drawing submittal.
- 2. Hardware Equipment Submittal: The CONTRACTOR shall submit a complete bound package at one time within 60 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 20 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. Flowmeter Sizing Calculations: Calculations shall be submitted on the instrument manufacturer letterhead and shall include the following:
    - 1) Guaranteed meter accuracy based on the upstream and downstream straight runs associated with the location of each meter.

- 2) Permanent head loss associated with each meter.
  - 3) Flow vs. differential pressure curves for each head-type device. For compressible fluids, curves shall be pressure- and temperature-compensated.
  - 4) References to ASME standard equations used.
  - 5) 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 and hard copy format. Each instrument shall have a dedicated 8-1/2" by 11" 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, and OWNER-furnished equipment which is to be incorporated into the SCADA system. The PLDS shall be a singular complete bound package electronically drafted, submitted within 120 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 5.4 and as defined by the most recent revision in ISA. 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 5.4 requirements, the loop diagrams shall also show the following details:
      - 1) Functional name of each loop.
      - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
      - 3) Panel, 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 software and shall be submitted on electronic media and hard copy. The instrument summary shall list all 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 SCADA system and its components.
  - b. Detailed 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: The CONTRACTOR shall submit a training plan which includes:
- a. Training plan overview.
  - b. Schedule of training courses including dates, durations, and locations of each class.
  - c. Resumes of the instructors who will actually implement the plan.

C. 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, Pre-Commissioning, and Performance Testing shall be included in Section H.
  - 4. Initially, two sets of draft Technical Manuals shall be submitted for review after return of favorably reviewed shop drawings and data required herein. Following the OWNER'S REPRESENTATIVE'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.
- D. Record Drawings:
- 1. The CONTRACTOR shall keep current a set of complete loop and schematic diagrams which shall include field and panel wiring, routing, mounting details, point-to-point diagrams with cable, wire, and termination numbers. These drawings shall include every instrument and instrument element. One set of drawings electronically formatted and two hard copies shall be submitted after completion of Pre-Commissioning tasks but prior to Performance Testing. Such drawings shall be submitted for review prior to acceptance of the completed WORK by the OWNER.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. **Code and Regulatory Compliance:** SCADA system WORK shall conform to or exceed the applicable requirements of the NEC. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.
- 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. **Hardware Commonality:** Instruments which utilize a common measurement principle (e.g. d/p cells, pressure transmitters, level transmitters that monitor hydrostatic head, etc.) 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.
- D. **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.
- E. **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. Use 2-wire transmitters over 4-wire transmitters wherever possible. 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.

- F. **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.
- G. **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.
- H. **Signal Levels:** Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals shall be 4 to 20 milliamperes dc, except as indicated. Electrical signals shall be electrically or optically isolated from other signals.
- I. **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.
- J. **Alternative Equipment and Methods:** Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the OWNER'S REPRESENTATIVE through the "or equal" process of the bid forms. 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 SCADA system shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:

Environment	Indoors, in a dry, cooled environment
Temperature Range	50 through 104 degrees F

Thermal Shock	1 degree F per minute, max
Relative Humidity	20 through 90 percent, non-condensing

## 2.3 CONTROL SYSTEM PRODUCTS

- A. All control system enclosures, components, and devices, including but not limited to PLCs, HMIs, power supplies, control relays, pilot devices, and network switches shall be provided in accordance with Section 40 90 05 – Control Enclosures and Devices.

## 2.4 SPARE PARTS AND SPECIAL TOOLS

- A. 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.
- B. Special tools and spare parts shall be submitted before startup commences, suitably wrapped and identified.

## 2.5 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 OWNER'S REPRESENTATIVE 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 OWNER'S REPRESENTATIVE prior to testing. No shipments shall be made without the OWNER'S REPRESENTATIVE'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 SCADA system. 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 OWNER'S REPRESENTATIVE. 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.
- B. Manufacturer's services shall be furnished for the following equipment:
1. Magnetic flowmeters 12" and larger.
  2. Vendor Control Panels with associated instrumentation and signals as specified in Section 40 90 18 – Vendor Package Control Systems.

### 3.3 INSTALLATION

A. **General:**

1. Instrumentation, including instrumentation furnished under other divisions, shall be installed under Division 40 and in accordance with 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.
2. Process equipment control wiring, 4-20 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. PLC equipment cables shall be provided under Division 40.
4. Terminations and wire identification at SCADA system 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. 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 OWNER'S REPRESENTATIVE for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.

**E. 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. Flexible cables shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
5. Power and signal wires shall be terminated with crimped type lugs.
6. Connectors shall be watertight at a minimum.
7. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.
8. 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 OWNER'S REPRESENTATIVE. Wiring shall be protected from sharp edges and corners.

9. Mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.
10. Verify the correctness of each installation, including polarity of 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.
11. 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 OWNER'S REPRESENTATIVE.
- D. **Field Calibration:** Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.
- E. **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.

F. **Calibration Tags:** A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the OWNER'S REPRESENTATIVE. The CONTRACTOR shall have the Instrumentation Supplier sign the tag when calibration is complete. The OWNER'S REPRESENTATIVE will sign the tag when the calibration and testing has been accepted.

### 3.5 LOOP TESTING

- A. **General:** Individual instrument loop diagrams per ISA 5.4, expanded format, shall be submitted to the OWNER'S REPRESENTATIVE for review prior to the loop tests. The CONTRACTOR shall notify the OWNER'S REPRESENTATIVE of scheduled tests a minimum of 30 days prior to the estimated completion date of installation and wiring of the SCADA system. After the OWNER'S REPRESENTATIVE'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 OWNER'S REPRESENTATIVE.
- 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 ensure 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 OWNER'S REPRESENTATIVE.
- E. **Loop Validation:**
  1. 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 PLC. Actual signals shall be used wherever available.

2. 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.
  3. 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.
  4. 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 OWNER'S REPRESENTATIVE 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 OF RECORD or the ENGINEER OF RECORD's representative as a witness, with test data entered, shall be submitted to the ENGINEER OF RECORD 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 as specified in the Calibration and Loop Testing paragraphs above, and after 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 OWNER'S REPRESENTATIVE. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the OWNER'S REPRESENTATIVE, which include calculated tolerance limits for each step. Completion of system pre-commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the OWNER'S REPRESENTATIVE 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 controls 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 two types of test forms as follows:

1. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:
  - a. Project name.
  - b. Loop number.
  - c. Loop description.
  - d. Tag number, description, manufacturer, and data sheet number for each component.
  - e. Space for sign-off and date by both the Instrumentation Supplier and OWNER'S REPRESENTATIVE.
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 OWNER'S REPRESENTATIVE.

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 OWNER'S REPRESENTATIVE before the performance testing may begin. Final acceptance of the control system shall be based upon project completion as stated in the General Conditions.

### 3.7 COMMISSIONING

- A. **General:** Commissioning shall commence after acceptance of the instrumentation and control system pre-commissioning completion report as specified in the Pre-Commissioning paragraph above.
- B. The entire WORK shall operate for 22 days longer than the commissioning period in Section 01 75 00 – Startup without failure.
- C. In addition to the commissioning requirements of Section 01 75 00 – Startup, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements.

- D. If any control component fails during the performance test, or if any error in logic occurs, it shall be repaired, replaced, or otherwise adjudicated, and the performance test shall be restarted at time zero on another 30-day period.
- E. If any unforeseen condition occurs during the performance test, the test shall be paused and the condition shall be evaluated within 24 hours. If the condition is determined to satisfy the three conditions listed for malfunction evaluation in Section 01 75 00 – Startup, then the test shall be permitted to resume at the elapsed time at which it was paused. If the condition does not satisfy all three of the above conditions, the unforeseen condition shall be repaired, replaced, or otherwise adjudicated, and the performance test shall be restarted at time zero on another 30-day period.

### 3.8 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 8 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 3 weeks in advance of when the courses are to be initiated. The OWNER'S REPRESENTATIVE 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.

### 3.9 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 SCADA system 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 OWNER.
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.

#### **PART 4 -- APPENDIX**

- A. **PLC I/O Schedule:** The following PLC I/O Schedule is a compilation of all process data points included in the WORK related specifically to the SCADA cabinet PLC (PLC-090). Process data points for the traveling screen PLC or microcontroller shall be as shown on the Drawings and as specified under Section 35 79 13 – Traveling Belt Intake Screen.

<b>PLC I/O Schedule</b>					
<b>Discrete Inputs</b>					
<b>I/O Designation</b>	<b>Description</b>	<b>PLC-090 Slot</b>	<b>Channel</b>	<b>Range</b>	<b>Type</b>
YA-200	Traveling Screen Fault	01	DI-0	On/Off	N.O. Contact
HH-280	Meter Vault Flood Alarm	01	DI-1	On/Off	N.O. Contact
LO-300	Coho Incubation Tank Low Level	01	DI-2	On/Off	N.C. Contact
LO-500	Chinook Incubation Tank A Low Level	01	DI-3	On/Off	N.C. Contact
LO-501	Chinook Incubation Tank B Low Level	01	DI-4	On/Off	N.C. Contact
LO-502	Chinook Incubation Tank C Low Level	01	DI-5	On/Off	N.C. Contact
LO-503	Chinook Incubation Tank D Low Level	01	DI-6	On/Off	N.C. Contact
EL-090	UPS Battery On	01	DI-7	On/Off	N.O. Contact
TR-090	UPS Low Battery	01	DI-8	On/Off	N.O. Contact
YA-090	UPS Unit Fault	01	DI-9	On/Off	N.O. Contact
YA-091	Surge Protection Fault	01	DI-10	On/Off	N.C. Contact
YA-092	Ethernet Switch Fault	01	DI-11	On/Off	N.O. Contact
SU-090	Loss of DC Power	01	DI-12	On/Off	N.C. Contact
	Spare	01	DI-13		
	Spare	01	DI-14		

	Spare	01	DI-15		
YA-290	Meter Vault Intrusion Alarm	02	DI-0	On/Off	N.C. Loop
YA-390	Coho Building Intrusion Alarm	02	DI-1	On/Off	N.C. Loop
YA-590	Chinook Building Intrusion Alarm	02	DI-2	On/Off	N.C. Loop
YA-591	Electrical Room Intrusion Alarm	02	DI-3	On/Off	N.C. Loop
YA-690	Spawning Building Intrusion Alarm	02	DI-4	On/Off	N.C. Loop
YA-660	Waste Drain Wet Well Pump 1 Fault	02	DI-5	On/Off	N.O. Contact
YA-661	Waste Drain Wet Well Pump 2 Fault	02	DI-6	On/Off	N.O. Contact
HH-662	Waste Drain Wet Well High Level Alarm	02	DI-7	On/Off	N.O. Contact
	Spare	02	DI-8		
	Spare	02	DI-9		
	Spare	02	DI-10		
	Spare	02	DI-11		
	Spare	02	DI-12		
	Spare	02	DI-13		
	Spare	02	DI-14		
EN-090	Silence Siren Pushbutton	02	DI-15	On/Off	N.O. Contact
<b>Discrete Outputs</b>					
YA-093	General System Fault	03	DO-0	On/Off	Digital Out
YA-094	Intrusion Alarm	03	DO-1	On/Off	Digital Out
EN-091	Annunciate Siren	03	DO-2	On/Off	Digital Out
LO-010	Incubation Tanks Low Water	03	DO-3	On/Off	Digital Out
	Spare	03	DO-4		
	Spare	03	DO-5		
	Spare	03	DO-6		
	Spare	03	DO-7		
<b>Analog Inputs</b>					
FL-200	Coho Building RW Supply Flow	04	AI-0	0 – 1,000 gpm	Analog, 4-20 mA
FL-201	Adult Holding Ponds RW Supply Flow	04	AI-1	0 – 4,500 gpm	Analog, 4-20 mA
FL-202	Chinook Raceways RW Supply Flow	04	AI-2	0 – 4,500 gpm	Analog, 4-20 mA
FL-203	Chinook Building RW Supply Flow	04	AI-3	0 – 750 gpm	Analog, 4-20 mA
LV-200	Fall Creek Head Level at Intake Structure	05	AI-0	0 – 5 ft W.C.	Analog, 4-20 mA
LV-201	Water Level Behind Traveling Screen	05	AI-1	0 – 5 ft W.C.	Analog, 4-20 mA

	Spare	05	AI-2		Analog, 4-20 mA
	Spare	05	AI-3		Analog, 4-20 mA

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## SECTION 40 90 05 - CONTROL ENCLOSURES AND DEVICES

### PART 1 -- GENERAL

#### 1.1 SUMMARY

- A. The CONTRACTOR shall provide control enclosures, control panels, control devices, and other control equipment for the WORK in accordance with this specification and the Contract Documents.
- B. The provisions of this section apply to all control enclosures, devices, and other related equipment of the WORK, except as indicated otherwise.
- C. Interconnecting wiring, raceway, and mounting hardware external to control panels shall be in accordance with the requirements of Division 26.
- D. In general, the provisions of Division 26 apply to materials furnished under this section. Where the requirements of this section conflict with Division 26 requirements, only the requirements of this section shall apply.

#### 1.2 REFERENCE STANDARDS

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

##### **National Electrical Manufacturers Association (NEMA)**

250	Enclosure for Electrical Equipment (1000 Volts Maximum)
AB 1	Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
ICS 1	Industrial Control and Systems: General Requirements
ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts
ICS 5	Control Circuit and Pilot Devices

##### **National Fire Protection Association (NFPA)**

70	National Electrical Code (NEC)
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##### **Underwriters Laboratories, Inc. (UL)**

44	Thermoset-Insulated Wires and Cables
83	Thermoplastic-Insulated Wires and Cables
486E	Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors
486F	Bare and Covered Ferrules
489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

508	Standard for Industrial Control Equipment
508A	Standard for Industrial Control Panels
1059	Standard for Terminal Blocks
1063	Standard for Machine-Tool Wires and Cables

### 1.3 SIGNAGE AND MARKINGS

- A. Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal and state OSHA and NEC requirements.

### 1.4 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals and individual equipment specification sections.
- B. All panel drawings shall, as a minimum, be 11 inches by 17 inches and data sheets and manufacturer specification sheets shall be 8-1/2 inches by 11 inches.
- C. **General Submittal Requirements:** Provide the following:
  1. Bill of material, with enumerated make and model of all devices used in construction of each control panel.
  2. Catalog cuts of bulletins or brochures for applicable standard equipment.
  3. Front, side, and backpanel elevations with dimensional data of each control panel, with matching enumeration to devices in bill of materials.
  4. Schematic and elementary diagrams.
  5. Interconnection diagrams that identify external connections between the control panel/control panel devices and associated equipment.
  6. Method of anchoring, seismic requirements, weight.
  7. Types of materials and finish.
  8. Nameplates.
  9. Voltage, phase, and current requirements.

### 1.5 SERVICE CONDITIONS

- A. **Ambient Temperature Range:**
  1. 50°F to 90°F for indoor equipment.
  2. 15°F to 100°F for outdoor equipment.
- B. **Site Elevation:** 2,500 feet above sea level.

## 1.6 QUALITY ASSURANCE

- A. Control panels shall be fabricated and wired in accordance with UL 508A and shall bear the UL label.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. Where there is more than one item of similar equipment being furnished all such similar equipment shall be the product of a singular manufacturer.
- B. Internal control components shall be mounted on an internal backpanel.
- C. Each separate source of externally derived voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front.
- D. Each control panel shall be provided with identified terminal strips for the connection of external conductors.
- E. Each motor starter shall be provided with relay dry-contacts for motor overload, local indication, and remote alarm, and as shown on Contract Drawings.
- F. Discrete outputs from the control panel shall be provided by dry contacts rated for 5 amps at 120 VAC. Analog inputs and outputs shall be isolated 4 to 20 mA, two-wire signals with power supply, unless noted otherwise.
- G. Control panel mounted devices shall be mounted a minimum of 3 feet above finished floor elevation.

### 2.2 CONTROL PANEL ENCLOSURE

- A. Enclosure shall be UL listed.
- B. Material shall be steel with 12-gauge minimum thickness.
- C. **Rating:** Enclosures shall be in accordance with NEMA 250 ratings and suitable for the environment in which they are installed:
  - 1. Indoor enclosures in dry areas shall be NEMA 1.
  - 2. Indoor enclosures in wet areas shall be NEMA 4 or better where spraying or splashing water may be present intermittently. Otherwise, enclosures shall be NEMA 3R or better.
  - 3. Outdoor enclosures shall be NEMA 3R or better.
  - 4. For areas not mentioned above, enclosures shall be NEMA 12 or better.
- D. All mounting hardware shall be stainless steel.

- E. Seams shall be continuously welded and ground smooth, with no holes or knockouts.
- F. Provide internal mounting channels welded horizontally to sides at top, bottom, and center of enclosure.
- G. Provide heavy duty lifting eyes.
- H. **Finish:** Exterior finish shall be white or stainless, as required. Interior finish shall be white.
- I. **Backpanel:**
  - 1. Installed inside enclosure at the rear for mounting control components.
  - 2. Painted steel with 14-gauge minimum thickness.
  - 3. Sized for the enclosure provided.
  - 4. Same finish as enclosure interior.
- J. **Doors:**
  - 1. Gasketed door with concealed, easy-to-remove hinges.
  - 2. Equipped with key-locking handle and three-point latch mechanism.
  - 3. Ground bonding provision on door.
  - 4. Data pocket inside door with handle, constructed of high-impact thermoplastic.
- K. **Device Mounting:**
  - 1. Provide door cutouts and mount pilot devices indicated to be door-mounted.
  - 2. Mount other accessory items behind the doors as required for complete functionality.
  - 3. Mounting devices to door shall not invalidate NEMA 250 enclosure rating. Furnish gaskets and other provisions to meet rating required.
- L. **Nameplates:**
  - 1. Provide control panel nameplate in accordance with Section 26 00 00 – Basic Electrical Requirements.
  - 2. Provide pilot device nameplates in accordance with Paragraph Pilot Devices herein, with inscriptions shown on drawings.
- M. **Environmental Suitability:** Control panel enclosure shall be suitable for operation in the ambient conditions associated with the locations designated in the drawings. 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.