



**Nevada Irrigation District –
Hemphill Diversion
Structure**

**Hemphill Diversion Structure—
Technical Specifications
100% Design Submittal**

**DRAFT
Revision No. 00**



March 2022

This page intentionally left blank.

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seals, as professional engineers licensed to practice as such, are affixed below.

CIVIL DESIGN
Kevin Jensen, P.E.

STRUCUTRAL DESIGN
Zachary Autin, P.E.

ELECTRICAL DESIGN
Matthew Lawson, P.E.

This page intentionally left blank.

NEVADA IRRIGATION DISTRICT – HEMPHILL DIVERSION STRUCTURE

VOLUME 1: TECHNICAL SPECIFICATIONS

100% DESIGN TABLE OF CONTENTS

Division 01 – General Requirements

Section 01 77 00 – Project Closeout

Division 02 – Existing Conditions

Section 02 22 00 – Site Condition Assessment

Section 02 41 00 – Demolition, Salvage, and Rehabilitation

Division 03 – Concrete

Section 03 11 13 – Concrete Formwork

Section 03 20 00 – Reinforcement Steel

Section 03 30 00 – CIP Concrete

Section 03 32 00 – Joints in Concrete

Section 03 60 00 – Grout

Section 03 65 00 – Epoxy Resin Adhesive Systems

Division 05 – Metals

Section 05 12 00 – Structural Steel Framing

Section 05 50 00 – Miscellaneous Metalwork

Division 26 – Electrical

Section 26 05 00 – Electrical Work, General

Section 26 05 02 – Miscellaneous Electrical Devices

Section 26 05 10 – Electric Motors

Section 26 05 19 – Insulated Wire and Cable

Section 26 05 26 – Grounding

Section 26 05 43 – Raceways

Section 26 08 00 – Electrical Testing

Division 31 – Earthwork

Section 31 00 00 – Earthwork

Section 31 03 10 – Diversion and Care of Stream During Construction

Section 31 11 00 – Site Preparation (Clearing and Grubbing)

Section 31 23 19 – Dewatering

Section 31 35 00 – Erosion and Sediment Control, General

Section 31 35 20 – Erosion Control Barrier

Section 31 35 29 – Erosion and Sediment Control Turbidity Curtain

Section 31 35 30 – Erosion Control (Vegetative)

Section 31 37 00 – Riprap

Section 31 41 16 – Sheet Piles

Division 33 – Utilities

Section 33 11 10 – Ductile Iron Pipe (AWWA C151)

Section 33 11 22 – PVC Pressure Pipe (AWWA C905)

Division 35 – Waterways and Marine Construction

Section 35 20 29 – Intake Screens

Section 35 20 30 - Automatic Undershot Control Gates

VOLUME 2: CONSTRUCTION DRAWINGS

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 01 77 00 - PROJECT CLOSEOUT

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide project closeout activities in accordance to the Contract Documents.

1.2 FINAL CLEANUP

- A. The CONTRACTOR shall promptly remove from the vicinity of the completed WORK, all rubbish, unused materials, concrete forms, construction equipment, and temporary structures and facilities used during construction. Final acceptance of the WORK by the OWNER will be withheld until the CONTRACTOR has satisfactorily performed the final cleanup of the Site.

1.3 CLOSEOUT TIMETABLE

- A. The CONTRACTOR shall establish dates for equipment testing, acceptance periods, and on-site instructional periods (as required under the Contract). Such dates shall be established not less than one week prior to beginning any of the foregoing items, to allow the OWNER, the ENGINEER, and their authorized representatives sufficient time to schedule attendance at such activities.

1.4 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of General Conditions Section 09 - Submittals.
- B. The CONTRACTOR, prior to requesting final inspection and payment, shall:
 - 1. Notify the District to perform a preliminary inspection for determining the state of completion of the project. Contractor shall notify the District at least seven days in advance of the time this inspection is to be performed. Before the District performs such inspection, the Contractor shall provide the District with the Contractor's Punch List, listing its observed Contract deficiencies. From the information gathered from this preliminary inspection, the District will prepare a punch list of work to be performed, corrected, or completed before the project will be accepted. Contractor shall complete all work on the punch list before final inspection.
 - 2. Clean the site and all applicable appurtenances and improvements to the satisfaction of the OWNER.
 - 3. Provide written guarantees/warranty, where required;
 - 4. Provide technical Manuals and instructions;
 - 5. Provide new permanent cylinders and key blanks for all locks;
 - 6. Provide maintenance stock items; spare parts; special tools;

7. Provide completed record drawings;
8. Provide bonds for roofing, maintenance, etc., as required;
9. Provide certificates of inspection and acceptance by local governing agencies having jurisdiction; and,
10. Provide releases from all parties who are entitled to claims against the subject project, property, or improvement pursuant to the provisions of law.

1.5 MAINTENANCE AND GUARANTEE

- A. The CONTRACTOR shall comply with the maintenance and guarantee requirements contained in Article 13 of the General Conditions.
- B. Replacement of earth fill or backfill, where it has settled below the required finish elevations, shall be considered as a part of such required repair work, and any repair or resurfacing constructed by the CONTRACTOR which becomes necessary by reason of such settlement shall likewise be considered as a part of such required repair work unless the CONTRACTOR shall have obtained a statement in writing from the affected private owner or public agency releasing the OWNER from further responsibility in connection with such repair or resurfacing.
- C. The CONTRACTOR shall make all repairs and replacements promptly upon receipt of written order from the OWNER. If the CONTRACTOR fails to make such repairs or replacements promptly, the OWNER reserves the right to do the WORK and the CONTRACTOR and its surety shall be liable to the OWNER for the cost thereof.

1.6 BOND

- A. The CONTRACTOR shall provide a bond to guarantee performance of the provisions contained in Paragraph "Maintenance and Guarantee" above, and Article 13 of the General Conditions.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 02 22 00 - SITE CONDITIONS ASSESSMENT

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall conduct thorough pre-construction and post-construction Site conditions surveys of the entire Project. Site conditions surveys shall consist of photographs and video recordings.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of General Conditions Section 9 - Submittals.
- B. Video surveys, photographs, and other data of the preconstruction conditions shall be submitted for record purposes prior to, but not more than three (3) weeks before, commencement of any construction activities.
- C. A complete set of all photographs and survey data of the post-construction conditions shall be completed and submitted prior to final inspection.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 PHOTOGRAPHS AND VIDEO RECORDINGS

- A. CONTRACTOR, as a minimum, shall document pre- and post-construction conditions by preparing video surveys of the following:
 - 1. roadways used to access the Site or haul materials and equipment to the Site;
 - 2. work areas, including actual work sites, materials processing and stockpiling areas, access corridors, disposal areas, and staging areas;
 - 3. any work completed by other contractors at the Site that will be connected to or otherwise affected by the WORK; and,
 - 4. driveways, sidewalks, and buildings which might be affected by the WORK.
- B. Supplement video surveys with photographs and spot elevation surveys as required to thoroughly document the original condition and location of existing features and facilities.
- C. Video records shall have electronic video file formats of MP4, WMV, AVI, or MOV.

PART 4 -- MEASUREMENT AND PAYMENT (NOT USED)

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 02 41 00 – DEMOLITION, SALVAGE, AND REHABILITATION

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall demolish and reconstruct existing civil, landscaping, structural, architectural, mechanical, HVAC, electrical, and instrumentation facilities as indicated, in accordance with the Contract Documents.

1.2 COORDINATION

- A. The CONTRACTOR shall carefully coordinate the WORK in areas where existing facilities are interconnected with new facilities and where existing facilities remain operational. The WORK as indicated is not all inclusive, and the CONTRACTOR shall be responsible to perform the reconstruction indicated plus that which can be reasonably inferred from the Contract Documents as necessary to complete the Project. The Specifications and Drawings identify the major facilities that shall be demolished and reconstructed, but auxiliary utilities such as water, air, chemicals, drainage, lubrication, fluid power, electrical wiring, controls, and instrumentation are not necessarily shown.
- B. The CONTRACTOR shall note that the Drawings used to indicate demolition and reconstruction are based on record drawings or site photographs of the existing facilities. These information sources have been reproduced to show existing conditions and to clarify the scope of WORK as much as possible. Prior to ground-disturbing activities, the CONTRACTOR shall conduct a comprehensive survey at the Site to verify the correctness and exactness of the Drawings, the scope of WORK, and the extent of auxiliary utilities.
- C. While demolition and reconstruction are being performed, the CONTRACTOR shall provide adequate access for the continued operation and maintenance of equipment and treatment processes. The CONTRACTOR shall erect and maintain fences, warning signs, barricades, and other devices around the reconstruction as required for the protection of the CONTRACTOR's employees and the OWNER's personnel. The CONTRACTOR shall remove such protection when reconstruction activities are complete, or as work progresses, or when directed by the ENGINEER.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of General Conditions Section 9 - Submittals.
- B. The CONTRACTOR shall submit a written operational sequence for the demolition and reconstruction activities and procedures. The procedures shall provide for safe conduct of the WORK, careful removal and disposition of materials and equipment, protection of existing facilities which are to remain undisturbed, coordination with existing facilities to remain in service, and timely disconnection and reconnection of utility services. The procedures shall include a detailed description and time schedule of the methods and equipment to be used for each operation and the sequence of operation. A storage plan for salvaged items shall be included.

1.4 DEMOLITION

- A. Existing pavement, structures, equipment, piping, valves, ductwork, electrical gear, instrumentation, utilities, and related appurtenances such as anchors, supports, and hardware indicated or required to be demolished as part of the WORK shall be removed and disposed of unless otherwise indicated. Removal of buried structures, utilities, and appurtenances includes the related excavation and backfill as required. Removed items shall be disposed of offsite by the CONTRACTOR.
- B. Items to be removed include:

Table 1-1. Demolition Schedule

Item	Description
Hemphill Diversion Dam	Concrete structure spanning the width of Auburn Ravine (Approx. 80 feet). The concrete structure is approximately 5 feet in length and includes footings approximately 5 feet deep. Demolition includes wing walls and all associated features and tree removal as indicated on the Drawings.
Hemphill Canal Headgate Structure	Concrete structure with trash rack and slide gate. 48" Diameter CMP pipe connecting Headgate structure to Hemphill Canal.
Hemphill Canal Gage	Concrete flume within Hemphill Canal

1.5 DISPOSAL

- A. The CONTRACTOR shall be responsible for the offsite disposal of debris resulting from reconstruction in compliance with local, state, and federal codes and requirements.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

- A. The CONTRACTOR shall coordinate demolition and reconstruction WORK with the OWNER and ENGINEER. Unless otherwise indicated, the CONTRACTOR shall be responsible for the sequence of activities. WORK shall be performed in accordance with applicable safety rules and regulations.
- B. The CONTRACTOR shall verify that any utilities connected to structures, equipment, and facilities to be removed, relocated, salvaged, replaced, or abandoned are rendered inoperable, replaced with new utilities, or adequately bypassed with temporary utilities before proceeding with demolition and reconstruction.
- C. The CONTRACTOR shall take precautions to avoid damage to adjacent facilities and to limit the WORK activities to the extent indicated. If reconstruction beyond the scope

indicated is required, the CONTRACTOR shall obtain approval from the ENGINEER prior to commencing.

3.2 PROTECTION OF EXISTING FACILITIES

- A. Before beginning any reconstruction, the CONTRACTOR shall carefully survey the existing facilities and examine the Specifications and Drawings to determine the extent of reconstruction and coordination with the WORK. Damaged existing facilities shall be repaired to the previous condition or replaced.
- B. Structural elements shall not be overloaded. The CONTRACTOR shall be responsible for shoring, bracing, or adding new supports as may be required for adequate structural support as a result of WORK performed under this Section. The CONTRACTOR shall remove temporary protection when the WORK is complete or when so authorized by the ENGINEER.
- C. The CONTRACTOR shall carefully consider bearing loads and capacities before placement of equipment and material on Site. In the event of any questions as to whether an area to be loaded has adequate bearing capacity, the CONTRACTOR shall consult with the ENGINEER prior to the placement of such equipment or material.

3.3 DEMOLITION, SALVAGE, AND RELOCATION

- A. The Contract Documents indicate existing facilities to be demolished, salvaged, and/or relocated. Auxiliary utilities including such services as water, air, chemicals, drainage, lubrication, fluid power, electrical wiring, controls, and instrumentation are not necessarily indicated. The removal of existing facilities for demolition, salvage, and relocation shall include the following requirements:
 - 1. Equipment supports, including concrete pads, baseplates, mounting bolts, and support hangers, shall be removed. Damage to the existing structure shall be repaired as indicated.
 - 2. Footings, foundation walls, below-grade construction and concrete slabs on grade shall be demolished and removed to a depth which will not interfere with new construction, but not less than 36-inches below existing ground surface or future ground surface, whichever is lower.
 - 3. Below-grade areas and voids resulting from demolition of structures shall be completely filled. Fill and compaction shall be in accordance with Section 31 00 00 - Earthwork. After fill and compaction, surfaces shall be graded to meet adjacent contours and to provide flow to surface drainage structures, or as indicated.
 - 4. The existing Measuring Station is to remain until the new station is in service. NID will remove the internal equipment. Contractor to remove remainder items.

3.4 DISPOSAL

- A. Demolition and removal of debris shall minimize interference with roads, streets, walks, and other adjacent occupied or used facilities which shall not be closed or obstructed

without permission from the OWNER. Alternate routes shall be provided around closed or obstructed traffic ways.

- B. Site debris, rubbish, and other materials resulting from reconstruction operations shall be legally removed and disposed of. Structures and equipment to be demolished shall be cleaned prior to demolition and the wash water properly disposed of. No trace of these structures shall remain prior to placing of backfill in the areas from which structures were removed.
- C. Refuse, debris, and waste materials resulting from demolition and clearing operations shall not be burned.

3.5 OCCUPANCY AND POLLUTION CONTROL

- A. Water sprinkling, temporary enclosures, chutes, and other suitable methods shall be used to limit dust and dirt rising and scattering in the area. The CONTRACTOR shall comply with government regulations pertaining to environmental protection.
- B. Water shall not be used if it creates hazardous or objectionable conditions such as ice, flooding, or pollution.

3.6 CLEANING

- A. During and upon completion of WORK, the CONTRACTOR shall promptly remove tools and equipment, surplus materials, rubbish, debris, and dust and shall leave areas affected by WORK in a clean, approved condition.
- B. Adjacent structures shall be cleaned of dust, dirt, and debris caused by reconstruction, as directed by the ENGINEER or governing authorities, and adjacent areas shall be returned to condition existing prior to start of WORK.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement for Demolition, Salvage, and Rehabilitation shall be made as a percent complete. This bid item is considered 100% complete when all Demolition, Salvage, and Rehabilitation has been completed as described in the Construction Specifications and Drawings.

4.2 PAYMENT

- A. Payments shall be based on percent complete applied against the contract lump sum price. The lump sum contract price for Demolition, Salvage, and Rehabilitation shall include full compensation for all labor, materials, tools, equipment, and incidentals for doing all work necessary for the tasks as described in these specifications. A description of work is included at the head of this section. Any work associated herewith and not included in this or other bid items shall be deemed as included in the contract price for demolition, salvage, and rehabilitation.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 03 11 13 - CONCRETE FORMWORK

PART 1 -- GENERAL

1.1 SUMMARY

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

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with General Conditions Section 9 - Submittals.
- B. Manufacturer's information demonstrating compliance with requirements for the following:
 - 1. Form ties and related accessories, including taper tie plugs, if taper ties are used.
 - 2. Form gaskets.
 - 3. Form release agent, including NSF certification if not using mineral oil.
 - 4. Manufacturer's information on formwork, form materials, and locations for use.
 - 5. Form Liners
- C. **Shop Drawings:** Detailed plans for the fabrication and erection of falsework to be used. Such plans shall be in sufficient detail to indicate the general layout, sizes of members, anticipated stresses, grade of materials to be used in the falsework, means of protecting existing construction which supports falsework, and typical soil conditions. Include a list of form materials and locations for use.
- D. **Falsework Calculations and Drawings:** The CONTRACTOR's attention is directed to the provisions of Section 1717 of the Division of Industrial Safety, Construction Safety Orders, as revised November 1973, which requires that all falsework or vertical shoring installations where the height of the falsework or vertical shoring, as measured from the top of the sills to the soffit of the superstructure, exceeds 14-feet, or where individual horizontal span lengths exceed 16-feet, or provision for vehicular or railroad traffic through falsework or vertical shoring is made, shall be approved and signed by a Professional Engineer, registered in the State in which the falsework or vertical Shoring is to be used; provided further, that a copy of the falsework plan or shoring layout shall be available on the Site at all times.

1.3 QUALITY CONTROL

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

PART 2 -- PRODUCTS

2.1 GENERAL

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

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

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

2.2 FORM AND FALSEWORK MATERIALS

- A. **Materials.** Materials for concrete forms, formwork, and falsework shall conform to the following requirements:
1. Lumber shall be Douglas Fir or Southern Yellow Pine, construction grade or better, in conformance with U.S. Product Standard PS 20 - American Softwood Lumber Standard
 2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Yellow Pine plywood manufactured especially for concrete formwork, shall conform to the requirements of PS 1 – Construction and Industrial Plywood, for Concrete Forms, Class I, and shall be edge sealed.
 3. Form materials shall be metal, wood, plywood, or other material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line, and grade indicated. Metal forms shall accomplish such results. Wood forms for surfaces to be painted shall be Medium Density Overlaid plywood, MDO Ext. Grade.
 4. Steel leave in place forms shall not be used.
- B. **Chamfer Edges.** Unless otherwise indicated, exterior corners in concrete members shall be provided with 3/4-inch chamfers or be tooled to 0.5-inch radius. Re-entrant corners in concrete members shall not have fillets unless otherwise indicated.
- C. **Load Criteria.** Forms and falsework to support the roof and floor slabs shall be designed for the total dead load, plus a live load of 50-psf minimum. The minimum design load for combined dead and live loads shall be 100-psf.

2.3 FORM TIES

- A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to insure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties or other removable form tie fasteners having a circular cross-section shall not exceed 1.5 inches; and all such fasteners shall be such as to leave holes of regular shape for reaming. Form ties for water-retaining structures shall have integral waterstops that tightly fit the form tie so that they cannot be moved from mid-point of the tie. Form ties shall be **ST Snap Ties** by **MeadowBurke**; **A3 Snap Ties** by **Dayton Superior** or approved equal.
- B. Removable taper ties may be used when approved by the ENGINEER. A preformed neoprene or polyurethane tapered plug sized to seat at the center of the wall shall be inserted in the hole left by the removal of the taper tie. Use **Taper Ties** by **MeadowBurke**, **D9 Taper Ties** by **Dayton Superior**, or approved equal.

PART 3 -- EXECUTION

3.1 GENERAL

- A. **Design Responsibility.** Forms to confine the concrete and shape it to the required lines shall be used wherever necessary. The CONTRACTOR shall assume full responsibility for the adequate design of forms, and any forms that are unsafe or inadequate in any respect shall promptly be removed from the WORK and replaced.
 - 1. A sufficient number of forms of each kind shall be available to permit the required rate of progress to be maintained.
 - 2. Provide worker protection from protruding reinforcement bars in accordance with applicable safety codes.
 - 3. The design and inspection of concrete forms, falsework, and shoring shall comply with applicable local, state, and Federal regulations.
 - 4. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by CONTRACTOR's personnel and by the ENGINEER and shall be in sufficient number and properly installed. During concrete placement, the CONTRACTOR shall continually monitor plumb and string line form positions and immediately correct deficiencies.
- B. **Quality Control & Bracing.** Concrete forms shall conform to the shape, lines, and dimensions of members required, and shall be substantial, free from surface defects, and sufficiently tight to prevent leakage. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly-placed concrete. If adequate foundation for shores cannot be secured, trussed supports shall be provided.
- C. All forms shall be removed, after the appropriate curing times have been obtained, unless approved otherwise by the ENGINEER.

3.2 FORM DESIGN

- A. Forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade, and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. Suitable and effective means shall be provided on forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete.
1. Plywood, 5/8-inch and greater in thickness, may be fastened directly to studding if the studs are spaced close enough to prevent visible deflection marks in the concrete.
 2. The forms shall be tight so as to prevent the loss of water, cement, and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1.0- to 1.5-inch diameter polyethylene rod held in position to the underside of the wall form.
 3. Adequate clean-out holes shall be provided at the bottom of each lift of forms. The size, number, and location of such clean-outs shall be as acceptable to the ENGINEER.
 4. Whenever concrete cannot be placed from the top of a wall form in a manner that meets the requirements of the Contract Documents, form windows shall be provided in the size and spacing needed to allow placement of concrete to the requirements of Section 03 30 00 - Cast-in-Place Concrete. The size, number, and location of such form windows shall be as acceptable to the ENGINEER.

3.3 CONSTRUCTION

- A. **Vertical Surfaces:** Vertical surfaces of concrete members shall be formed, except where placement of the concrete against the ground is indicated. Not less than 1-inch of concrete shall be added to the indicated thickness of a concrete member where concrete is permitted to be placed against trimmed ground in lieu of forms. Permission to do this on other concrete members will be granted only for members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.
- B. **Construction Joints:** Concrete construction joints will not be permitted at locations other than those indicated, except as may be acceptable to the ENGINEER. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location, and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. Pipe stubs and anchor bolts shall be set in the forms where required.
- C. **Form Ties**

1. **Embedded Ties:** Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar. Wire ties for holding forms will not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete members. The use of snap-ties that cause spalling of the concrete upon form stripping or tie removal will not be permitted. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 1-inch back from the formed face or faces of the concrete.
2. **Removable Ties:** Where taper ties are approved for use, the larger end of the taper tie shall be on the wet side of walls in water retaining structures. After the taper tie is removed, the hole shall be thoroughly cleaned and roughened for bond. A precast neoprene or polyurethane tapered plug shall be located at the wall centerline. The hole shall be completely filled with non-shrink grout for water bearing and below-grade walls. The hole shall be completely filled with non-shrink or regular cement grout for above-grade walls that are dry on both sides. Exposed faces of walls shall have the outer 2-inches of the exposed face filled with a cement grout that shall match the color and texture of the surrounding wall surface.

3.4 REUSE OF FORMS

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

3.5 REMOVAL OF FORMS

- A. Careful procedures for the removal of forms shall be strictly followed, and this WORK shall be done with care so as to avoid injury to the concrete. No heavy loading on green concrete will be permitted.
 1. For roof slabs and above-ground floor slabs, forms shall remain in place until test cylinders for the roof concrete attain a minimum compressive strength of 75 percent of the 28 Day strength in Section 03 30 00 - Cast-in-Place Concrete. No forms shall be disturbed or removed under an individual panel or unit before the concrete in the adjacent panel or unit has attained 75 percent of the 28 Day strength and has been in place for a minimum of 7 Days. The time required to establish said strength shall be as determined by the ENGINEER who will make several test cylinders for this purpose from concrete used in the first group of roof panels placed. If the time so determined is more than the 7 Day minimum, then that time shall be used as the minimum length of time.

2. For vertical walls of water holding structures, forms shall remain in place at least 36 hours after the concrete has been placed.
3. For parts of the WORK not specifically mentioned herein, forms shall remain in place for periods of time as recommended in ACI 347 - Guide to Formwork for Concrete.

3.6 MAINTENANCE OF FORMS

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

3.7 FALSEWORK

- A. The CONTRACTOR shall be responsible for the design, engineering, construction, maintenance, and safety of falsework, including staging, walkways, forms, ladders, and similar appurtenances, which shall equal or exceed the applicable requirements of the provisions of the OSHA Safety and Health Standards for Construction, the requirements of the Construction Safety Orders of the California Division of Industrial Safety, and the requirements herein.
- B. Falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time.
- C. Falsework shall be placed upon a solid footing, safe against undermining, and be protected from softening. When the falsework is supported on timber piles, the maximum calculated pile loading shall not exceed 20-tons. When falsework is supported on any portion of the structure which is already constructed, the load imposed by the falsework shall be spread, distributed, and braced in such a way as to avoid any possibility of damage to the structure.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 03 30 00 Cast-in-Place Concrete. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 03 30 00 – Cast-in-Place Concrete.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 03 20 00 - REINFORCEMENT STEEL

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide reinforcement steel and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with General Conditions Section 9 - Submittals.

B. **Shop Drawings**

1. Shop bending diagrams, placing lists, and drawings of reinforcement steel prior to fabrication. The shop bending diagrams shall show the actual lengths of bars to the nearest inch measured to the intersection of the extensions (tangents for bars of circular cross section) of the outside surface. Include bar placement diagrams that clearly indicate the dimensions of each bar splice.
2. Details of the concrete reinforcement steel and concrete inserts shall be submitted at the earliest possible date after receipt by the CONTRACTOR of the Notice to Proceed. Said details of reinforcement steel for fabrication and erection shall conform to ACI 315 - Details and Detailing of Concrete Reinforcement and the requirements herein.

1.3 QUALITY CONTROL

- A. If requested by the ENGINEER, the CONTRACTOR shall furnish samples from each heat of reinforcement steel in a quantity adequate for testing. Costs of initial tests will be paid by the OWNER. Costs of additional tests if material fails initial tests shall be the CONTRACTOR's responsibility.

PART 2 -- PRODUCTS

2.1 MATERIAL REQUIREMENTS

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

2.2 REINFORCEMENT STEEL

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

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

B. **Accessories**

1. Accessories shall include necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers, and other devices to position reinforcement during concrete placement. Bar supports shall meet the requirements of the CRSI Manual of Standard Practice, including special requirements for supporting epoxy-coated reinforcing bars. Wire bar supports shall be CRSI Class 1 for maximum protection with a 1/8-inch minimum thickness of plastic coating that extends at least 0.5-inch from the concrete surface. Plastic shall be gray in color.
2. Concrete blocks (i.e. dobies) used to support and position reinforcement steel shall have the same or higher compressive strength as required for the concrete in which they are located. Wire ties shall be embedded in concrete block bar supports.

2.3 EPOXY GROUT

- A. Epoxy for grouting reinforcing bars shall be specifically formulated for such application, for the moisture condition, application temperature, and orientation of the hole to be filled. Epoxy grout shall meet the requirements of Section 03 60 00 - Grout.

PART 3 -- EXECUTION

3.1 GENERAL

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

3.2 FABRICATION

A. General

1. Reinforcement steel shall be accurately formed to the dimensions and shapes indicated, and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318 - Building Code Requirements for Reinforced Concrete, except as modified by the Drawings. Bars shall be bent cold. Bars shall be bent per ACI 318.
2. The CONTRACTOR shall fabricate reinforcement bars for structures in accordance with bending diagrams, placing lists, and placing drawings.

- B. **Fabricating Tolerances:** Bars used for concrete reinforcement shall satisfy the following fabricating tolerances:

1. Sheared length: plus and minus 1-inch
2. Depth of truss bars: plus zero, minus 0.5-inch
3. Stirrups, ties, and spirals: plus and minus 0.5-inch
4. Other bends: plus and minus 1-inch

3.3 PLACING

- A. Reinforcement steel shall be accurately positioned as indicated and shall be supported and wired together to prevent displacement, using annealed iron wire ties or suitable clips at intersections. Reinforcement steel shall be supported by concrete, plastic or metal support spacers, or metal hangers that are strong and rigid enough to prevent any displacement of the reinforcement steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the bars without settlement, but in no case shall such support be continuous. Concrete blocks used to support reinforcement steel shall be tied to the steel with wire ties that are embedded in the blocks. For concrete over formwork, the CONTRACTOR shall provide concrete, metal, plastic, or other acceptable bar chairs and spacers.
- B. Limitations on the use of bar support materials shall be as follows.
 - 1. Concrete Dobies
 - a. Permitted at any location except where architectural finish is required.
 - 2. Wire Bar Supports: permitted only at slabs over dry areas, interior dry wall surfaces, and exterior wall surfaces.
 - 3. Plastic Bar Supports: permitted at every location except on grade.
- C. Tie wires shall be bent away from the forms in order to provide the required concrete coverage.
- D. Bars additional to those indicated that may be found necessary or desirable by the CONTRACTOR for the purpose of securing reinforcement in position shall be provided by the CONTRACTOR at its own expense.
- E. Unless otherwise indicated, reinforcement placing tolerances shall be within the limits in Section 7.5 of ACI 318 except where in conflict with the Building Code.
- F. Bars may be moved as necessary to avoid interference with other reinforcement steel, conduits, or embedded items. If bars are moved more than one bar diameter or enough to exceed the above tolerances, the resulting arrangement of bars shall be as reviewed and accepted by the ENGINEER.
- G. Accessories supporting reinforcing bars shall be spaced such that there is no deflection of the accessory from the weight of the supported bars. When used to space the reinforcing bars from wall forms, the forms and bars shall be located so that there is no deflection of the accessory when the forms are tightened into position.

3.4 SPACING OF BARS

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

- B. Where reinforcement in beams or girders is placed in 2 or more layers, the clear distance between layers shall be not less than one inch.
- C. In columns, the clear distance between longitudinal bars shall be not less than 1.5 times the bar diameter, nor less than 1.5 times the maximum size of the coarse aggregate, nor less than 1.5-inches.
- D. The clear distance between bars shall also apply to the distance between a contact splice and adjacent splices or bars.

3.5 SPLICING

A. **General**

- 1. Reinforcement bar splices shall only be used at locations indicated. When it is necessary to splice reinforcement at points other than where indicated, the character of the splice shall be as reviewed and accepted by the ENGINEER.
- 2. Unless otherwise indicated, dowels shall match the size and spacing of the spliced bar.

B. **Splices of Reinforcement**

- 1. The length of lap for reinforcement bars, unless otherwise indicated, shall be in accordance with ACI 318, Section 12.15.1 for a Class B splice.
- 2. Splices in column spiral reinforcement, when necessary, shall be made by welding or by a lap of 1.5 turns.

- C. **Bending or Straightening:** Reinforcement shall not be straightened or rebent in a manner which will injure the material. Bars shall be bent or straight as indicated. Do not use bends different from the bends indicated. Bars shall be bent cold, unless otherwise permitted by the ENGINEER. No bars partially embedded in concrete shall be field-bent

3.6 CLEANING AND PROTECTION

- A. Reinforcement steel shall always be protected from conditions conducive to corrosion until concrete is placed around it.
- B. The surfaces of reinforcement steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcement shall be reinspected and, if necessary, recleaned.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 03 30 00 Cast-in-Place Concrete. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 03 30 00 – Cast-in-Place Concrete.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide cast-in-place concrete in accordance with the Contract Documents.
- B. The term "hydraulic structure" used in these Specifications means environmental engineering concrete structures for the containment, treatment, or transmission of water, wastewater, other fluids, or gases.
- C. The following types of concrete are covered in this Section:
 - 1. **Structural Concrete**
 - a. Regular Mix: Roof, floor slabs, columns, walls, pavements, and other concrete items not indicated otherwise in the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with General Conditions Section 9 - Submittals.
- B. **Mix Designs:** Prior to beginning the WORK and within 14 Days of the Notice to Proceed, submit preliminary concrete mix designs which shall show the proportions and gradations of materials proposed for each class and type of concrete. Mix designs shall be checked through laboratory testing by an independent testing laboratory acceptable to the ENGINEER. Costs related to laboratory testing shall be CONTRACTOR's responsibility as part of the WORK.
- C. **Delivery Tickets:** Where ready-mix concrete is used, the CONTRACTOR shall furnish delivery tickets at the time of delivery of each load of concrete. Each ticket shall show the state-certified equipment used for measuring and the total quantities, by weight, of cement, sand, each class of aggregate, admixtures, the amount of water in the aggregate added at the batching plant, and the amount allowed to be added at the Site for the specific design mix. In addition, each ticket shall state the mix number, total yield in cubic yards, and the time of day, to the nearest minute, corresponding to the times when the batch was dispatched, when it left the plant, when it arrived at the Site, when unloading began, and when unloading was finished.
- D. **Additional Submittals.** Test data relating to the cement, aggregate, and admixtures shall be less than 6 months old. Furnish the following submittals in accordance with ACI 301 – Structural Concrete:
 - 1. Mill tests for cement.
 - 2. Admixture certification. Chloride ion content shall be included.
 - 3. Aggregate gradation test results and certification.

4. Materials and methods for curing.

1.3 CONCRETE CONFERENCE

- A. The ENGINEER will chair a meeting to review the detailed requirements of the CONTRACTOR's proposed concrete design mixes and to determine the procedures for producing proper concrete construction no later than 14 Days after the Notice to Proceed.
- B. Parties involved in the concrete WORK shall attend the conference, including the following at a minimum:
 1. CONTRACTOR's representative
 2. Testing laboratory representative
 3. Concrete Subcontractor
 4. Reinforcing steel Subcontractor and detailer
 5. Concrete Supplier
 6. Admixture manufacturer's representative
- C. The conference shall be held at a time and place proposed by the CONTRACTOR and accepted by the ENGINEER. The conference shall be held at least 5 Days after agreement.

1.4 QUALITY CONTROL

A. **General**

1. Tests on component materials and for compressive strength and shrinkage of concrete shall be performed as indicated. Tests for determining slump shall be in accordance with ASTM C 143 – Test Method for Slump of Hydraulic Cement Concrete.
2. Testing for aggregate shall include sand equivalence, reactivity, organic impurities, abrasion resistance, and soundness, according to ASTM C 33 – Concrete Aggregates.
3. The cost of laboratory tests on cement, aggregates, and concrete shall be the CONTRACTOR's responsibility. The cost of laboratory tests on field-placed cement, aggregates, and concrete will be the CONTRACTOR'S responsibility. The laboratory shall meet or exceed ASTM C 1077 – Practice for Laboratories Testing Concrete and Concrete Aggregates for use in Construction and Criteria for Laboratory Evaluation.
4. Concrete for testing shall be furnished by the CONTRACTOR, and the CONTRACTOR shall assist the ENGINEER in obtaining samples and disposal and cleanup of excess material.

B. Field Compression Tests

1. Each set of specimens shall be a minimum of 5 cylinders.
2. Compression test specimens for concrete shall be made in accordance with Section 9.2 of ASTM C 31 – Practices for Making and Curing Concrete Test Specimens in the Field. Specimens shall be 6-inches diameter by 12-inches tall cylinders.
3. Frequency of Testing
 - 1) Sampling frequency and testing for each class of concrete shall be in accordance with ACI 350 section 5.5 as follows:
 - a) Not less than once a day for each class of concrete placed, nor less than:
 - b) Once for each 100 yd³ of each class of concrete placed each day, nor less than:
 - c) Once for each 5,000 ft² of slab or wall surface area placed each day.
 - d) If total volume of concrete is such that frequency of testing would provide less than five strength tests for a given class of concrete, tests shall be made from at least five randomly selected batches or from each batch if fewer than five batches are used.
 - 2) Frequency of testing may be changed at the discretion of the ENGINEER.
4. Compression tests shall be performed in accordance with ASTM C 39 – Test Method for Compressive Strength of Cylindrical Concrete Specimens. One test cylinder will be tested at 7 Days and 2 at 28 Days. The remaining cylinders will be held to verify test results, if needed.

C. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete will be according to ACI 318 – Building Code Requirements for Reinforced Concrete, Chapter 5 "Concrete Quality," and as indicated.
2. A statistical analysis of compression test results will be performed according to ACI 214 – Recommended Practice for Evaluation of Strength Test Methods. The standard deviation of the test results shall not exceed 640 psi, when ordered at equivalent water content as estimated by slump.
3. If any concrete fails to meet these requirements, immediate corrective action shall be taken to increase the compressive strength for subsequent batches of the type of concrete affected.
4. When the standard deviation of the test results exceeds 640 psi, the average strength for which the mix is designed shall be increased by an amount necessary to satisfy the statistical requirement that the probability of any test being more than

500 psi below or the average of any 3 consecutive tests being below the required compressive strength is 1 in 100. The required average strength shall be calculated by Criterion No. 3 of ACI 214 using the actual standard deviation.

5. Concrete that fails to meet the ACI requirements and these Specifications is subject to removal and replacement.
- D. **Aggregate Testing:** Aggregate testing shall be performed within 12 months of the start of construction and every 12 months during construction to determine continued compliance.
- E. **Construction Tolerances:** The CONTRACTOR shall set and maintain concrete forms and perform finishing operations to ensure that the completed WORK is within tolerances. Surface defects and irregularities are defined as finishes and are different from tolerances. Tolerance is the permissible variation from lines, grades, or dimensions indicated on the Drawings. Where tolerances are not stated in the Specifications, permissible deviations will be in accordance with ACI 117 – Standard Tolerance for Concrete Construction and Materials.
1. The following non-cumulative construction tolerances apply to finished walls and slabs unless otherwise indicated:

Item	Tolerance
Variation of the constructed linear outline from the established position in plan.	In 10-feet: 1/4-inch; In 20-feet or more: 1/2-inch
Variation from the level or from the grades indicated.	In 10-feet: 1/4-inch; In 20-feet or more: 1/2-inch
Variation from plumb	In 10-feet: 1/4-inch; In 20-feet or more: 1/2-inch
Variation in the thickness of slabs and walls.	Minus 1/4-inch; Plus 1/2-inch
Variation in the locations and sizes of slabs and wall openings	Plus or minus 1/4-inch

PART 2 -- PRODUCTS

2.1 CONCRETE MATERIALS

A. General

1. Materials shall be classified as acceptable for potable water use according to NSF Standard 61.

2. Ready-mix concrete shall conform to the requirements of ASTM C 94 – Ready Mixed Concrete.
 3. Cement for concrete that will contact potable water shall not be obtained from kilns that burn metal rich hazardous waste fuel.
 4. Materials shall be delivered, stored, and handled so as to prevent damage by water or breakage. Cement reclaimed from cleaning bags or leaking containers shall not be used. Cement shall be used in the sequence of receipt of shipments.
- B. Storage of materials shall comply with ACI 301, as applicable.
- C. **Materials.** Materials for concrete shall comply with ACI 301 and shall conform to the following requirements:
1. **Cement.** Cement shall be standard brand portland cement conforming to ASTM C 150 –Portland Cement, for Type I/II or Type V. A minimum of 85 percent of cement by weight shall pass a 325 screen. A single brand of cement shall be used throughout the WORK, and prior to its use, the brand shall be accepted by the ENGINEER. The cement shall be suitably protected from exposure to moisture until used. Cement that has become lumpy shall not be used. Sacked cement shall be stored in such a manner so as to permit access for inspection and sampling. Certified mill test reports, including fineness, for each shipment of cement to be used shall be submitted to the ENGINEER, if requested, regarding compliance with the Specifications.
 2. **Water.** Water for mixing and curing shall be potable, clean, and free from objectionable quantities of silty organic matter, alkali, salts, and other impurities. The water shall be considered potable, for the purposes of this Section only, if it meets the requirements of the local governmental agencies. Agricultural water with high total dissolved solids (greater than 1000 mg/l TDS) shall not be used.
 3. **Aggregates.** Aggregates shall be obtained from pits acceptable to the ENGINEER, shall be non-reactive, and shall conform to ASTM C 33 – Concrete Aggregates. Maximum size of coarse aggregate shall be as indicated. Substituting lightweight sand for fine aggregate will not be permitted.
 - a. Coarse aggregates shall consist of clean, hard, durable gravel, crushed gravel, crushed rock, or a combination thereof. The coarse aggregates shall be prepared and handled in 2 or more size groups for combined aggregates with a maximum size greater than 3/4-inch. When the aggregates are proportioned for each batch of concrete, the 2 size groups shall be combined.
 - b. Fine aggregates shall be natural sand or a combination of natural and manufactured sand that is hard and durable. When tested in accordance with ASTM D 2419 – Test Methods for Sand Equivalent Value of Soils and Fine Aggregate, the sand equivalency shall not be less than 75 percent for an average of 3 samples, nor less than 70 percent for an individual test. Gradation of fine aggregate shall conform to ASTM C 33 when tested in

accordance with ASTM C 136 for the fineness modulus of the sand used, including the optional grading in Section 6.2. The fineness modulus of sand used shall not be over 3.1.

c. Combined aggregates shall be well graded from coarse to fine sizes and shall be uniformly graded between screen sizes to produce concrete that has optimum workability and consolidation characteristics. Where a trial batch is required for a mix design, the final combined aggregate gradations will be established during the trial batch process.

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

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

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

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

4. **Flyash.** If used, flyash shall be Class F and meet ASTM C618.

5. **Admixtures.** Admixtures shall be compatible and be furnished by a single manufacturer capable of providing qualified field service representation. Admixtures shall be used in accordance with manufacturer's recommendations. If the use of an admixture is producing an inferior end result, the CONTRACTOR shall discontinue use of the admixture. Admixtures shall not contain thiocyanates nor more than 0.05 percent chloride ion, and shall be non-toxic after 30 days.

a. **Air-entraining agents:** Agents shall meet the requirements of ASTM C 260 – Air Entraining Admixtures for Concrete shall be used. Concrete floors to receive a dry-shake floor hardener shall have an air content not to exceed 3 percent. The OWNER reserves the right, at any time, to sample and test the air-entraining agent. The air-entraining agent shall be added to the batch in a portion of the mixing water. The solution shall be batched by means of a mechanical batcher capable of accurate measurement. Air content shall be tested at the point of placement. Air-entraining admixture shall be approved by the ENGINEER prior to use.

b. **Set controlling and water reducing admixtures:** Admixtures may be added at the CONTRACTOR's option, subject to the ENGINEER's approval, to control the set, effect water reduction,

and increase workability. The cost of adding an admixture shall be the CONTRACTOR's responsibility. Concrete containing an admixture shall be first placed at a location determined by the ENGINEER. Admixtures shall conform to ASTM C 494 – Chemical Admixtures for Concrete. The required quantity of cement shall be used in the mix regardless of whether or not an admixture is used.

- 1) Concrete shall not contain more than one water reducing admixture.
- 2) Set controlling admixture may be either with or without water-reducing properties. Admixture shall be appropriate for the air temperature at time of placement. Set controlling admixture shall be approved by the ENGINEER prior to use.
- 3) Normal range water reducer shall conform to ASTM C 494, Type A. The quantity of admixture used and the method of mixing shall be in accordance with the manufacturer's instructions and recommendations. Normal range water reducing admixtures shall be approved by the ENGINEER prior to use.
- 4) High range water reducer shall conform to ASTM C 494, Type F or G. High range water reducer shall be added to the concrete after all other ingredients have been mixed and initial slump has been verified. No more than 14 ounces of water reducer per sack of cement shall be used. Water reducer shall be considered as part of the mixing water when calculating the water/cement ratio. High range water reducing admixtures shall be approved by the ENGINEER prior to use.
- 5) If the high range water reducer is added to the concrete at the Site, it may be used in conjunction with the same water reducer added at the batch plant. Concrete shall have a slump of 3-inches plus or minus 1/2-inch prior to adding the high range water reducing admixture at the Site. The high range water reducing admixture shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician. A standby system shall be provided and tested prior to each day's operation of the primary system.
- 6) Concrete shall be mixed at mixing speed for a minimum of 70 mixer revolutions or 5 minutes after the addition of the high range water reducer, unless recommended otherwise by the manufacturer.

6. **Lithium Additives:** Lithium additives shall not be used in concrete mix design for water bearing structures.

2.2 CURING MATERIALS

A. Curing compounds shall be resin-based and compliant with local VOC requirements.

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

Sodium silicate compounds shall not be allowed. Concrete curing compound shall be approved by the ENGINEER prior to use.

2. When curing compound must be removed for finishes or grouting, compounds shall be a dissipating type meeting ASTM C 309, type 1 or 2, Class B. Concrete curing compound shall be approved by the ENGINEER prior to use.
- B. Polyethylene sheet for use as concrete curing blanket shall be white and shall have a nominal thickness of 6-mils. The loss of moisture when determined in accordance with ASTM C 156 – Test Method for Water Retention by Concrete Curing Materials, shall not exceed 0.055 grams per square centimeter of surface.
 - C. Polyethylene-coated waterproof paper sheeting for use as concrete curing blanket shall consist of white polyethylene sheeting free of visible defects, uniform in appearance, have a nominal thickness of 2-mils, and be permanently bonded to waterproof paper conforming to the requirements of Federal Specification UU-B-790A – Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellant and Fire Resistant). The loss of moisture, when determined in accordance with ASTM C 156, shall not exceed 0.055 gram per square centimeter of surface.
 - D. Polyethylene-coated burlap for use as concrete curing blanket shall be 4-mils thick with white opaque polyethylene film impregnated or extruded into one side of the burlap. Burlap shall weigh not less than 9 ounces per square yard. The loss of moisture, when determined in accordance with ASTM C 156, shall not exceed 0.055 grams per square centimeter of surface.
 - E. Curing mats for use in Curing Method 6 below shall be heavy shag rugs or carpets or cotton mats quilted at 4-inches on center. Curing mats shall weigh a minimum of 12 ounces per square yard when dry.
 - F. Evaporation retardant shall be a material such as **MasterKure ER 50** by **BASF**, **Eucobar** by **Euclid Chemical Company**, **L&M E-CON** by **Laticrete**, or equal.

2.3 NON-WATERSTOP JOINT MATERIALS

- A. Materials for non-waterstop joints in concrete shall conform to the following requirements:
 1. Preformed joint filler shall be a non-extruding neoprene sponge or polyurethane type conforming to Section 03290 - Joints in Concrete.
 2. Elastomeric joint sealer shall conform to Section 07920 - Sealants and Caulking.
 3. Mastic joint sealer shall be a material that does not contain evaporating solvents; that will tenaciously adhere to concrete surfaces; that will remain permanently resilient and pliable; that will not be affected by continuous presence of water and will not in any way contaminate potable water; and that will effectively seal the joints against moisture infiltration even when the joints are subject to movement from expansion and contraction. The sealer shall be composed of special asphalts or similar materials blended with lubricating and plasticizing agents to form a tough, durable mastic substance containing no volatile oils or lubricants and shall be

capable of meeting the test requirements set forth below, if testing is required by the ENGINEER.

2.4 MISCELLANEOUS MATERIALS

A. **Bonding Agents.** Bonding agents shall be epoxy adhesives conforming to the following:

1. For bonding freshly-mixed, plastic concrete to hardened concrete, **Sikadur 32 Hi-Mod Epoxy Adhesive** by **Sika Corporation**, **MasterEmaco ADH 326** by **BASF**, **Sure Bond J58** by **Dayton Superior**, or equal.
2. For bonding hardened concrete or masonry to steel, **Sikadur 31 Hi-Mod Gel** by **Sika Corporation**, **MasterEmaco ADH 327** by **BASF**, or equal.

B. **Vapor Retarder**

1. Vapor retarder shall be 30-mils thick, Class A, 3 ply, nylon or polyester cord-reinforced high density polyethylene sheet laminated to a non-woven geotextile fabric, in accordance with ASTM E 1745 - Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs.
2. Granular Material Above Vapor Retarder: Crushed stone, gravel, or sand with the following size distribution and meeting the deleterious substance limits of ASTM C 33 for fine aggregates.

Sieve Size	Percentage Passing
3/8-inch	100
4.75 mm	85-100
No. 100	10 – 30

3. Seams in vapor retarder sheet shall be sealed with tape, adhesive, or other material as recommended by sheet manufacturer for the areas to be sealed and sheet material.

2.5 CONCRETE DESIGN REQUIREMENTS

A. **General:** Concrete shall be composed of cement, admixtures, aggregates, and water of the qualities indicated. In general, the mix shall be designed to produce a concrete capable of being deposited so as to obtain maximum density and minimum shrinkage, and where deposited in forms, to have good consolidation properties and maximum smoothness of surface. The aggregate gradations shall be formulated to provide fresh concrete that will not promote rock pockets around reinforcing steel or embedded items. The proportions shall be changed whenever necessary or desirable to meet the required results. Changes shall be subject to review by the ENGINEER.

- B. **Fine Aggregate Composition:** In mix designs for structural concrete, the percentage of fine aggregate in total aggregate by weight shall be as indicated in the following table.

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

1. For other concrete, the maximum percentage of fine aggregate of total aggregate by weight shall not exceed 50.
- C. Duct bank concrete shall contain an integral red-oxide coloring pigment. Concrete shall be dyed red throughout. Surface treatment to color duct banks will not be acceptable.
- D. **Water/Cement Ratio W/C:** The water/cement ratio indicated is for saturated-surface dry condition of aggregate. Every Day, throughout the day, the batch water added shall be adjusted for the total free water in the aggregates.

1. Total free moisture of aggregates shall be determined by:
 - a. Starting with the total moisture content of all aggregate, calculated by ASTM C 566 -Test Method for Total Moisture Content of Aggregate by Drying
 - b. Subtracting the moisture absorbed by the coarse aggregate, calculated by ASTM C 127 – Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
 - c. Subtracting the moisture absorbed by the fine aggregate, calculated by ASTM C 128 – Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Fine Aggregate

E. **Concrete Property Tables**

Structural Concrete			
Type of WORK	Regular Mix		
	(slabs, walls, pavements, and other concrete items not		

	categorized elsewhere)		
Min 28 Day Compressive Strength, psi	4500		
Max Aggregate Size, in	1		
Cement Content, lbs /cubic yard,	564 to 600		
Max Allowable Fly Ash Content (FA); lbs/cubic yard	Up to 120, 150 (i.e up to 15% max of cement content)		
Max W/C Ratio by weight	0.42		
Total Air Content, percent	3 to 6		
Slump, in	3-in +/- 1-in with high range water reducer		
	7-in +/- 2-in		

--	--	--	--

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

- F. **Adjustments to Mix Design:** The CONTRACTOR may elect to decrease the water/cement ratio to achieve the strength and shrinkage requirements and/or add water reducers, as required to achieve workability. The mixes shall be changed whenever such change is necessary or desirable to secure the required strength, density, workability, and surface finish, and the CONTRACTOR shall be entitled to no additional compensation because of such changes. Any changes to the accepted concrete mix design shall be submitted to the ENGINEER for review and shall be tested again in accordance with these Specifications.

2.6 CONSISTENCY

- A. The quantity of water in a batch of concrete shall be just sufficient, with a normal mixing period, to produce a concrete that can be worked properly into place without segregation and which can be compacted by vibratory methods to give the desired density, impermeability, and smoothness of surface. The quantity of water shall be changed as necessary, with variations in the nature or moisture content of the aggregates, to maintain uniform production of a desired consistency. The consistency of the concrete in successive batches shall be determined by slump tests in accordance with ASTM C 143 – Test Method for Slump of Hydraulic Cement Concrete. The slumps shall be as indicated with the concrete properties.

2.7 TRIAL BATCH AND LABORATORY TESTS

- A. The CONTRACTOR shall only use a mix design for construction that has first met the trial batch testing requirements or approved historical concrete testing results as specified below.
1. **Trial Batch Concrete Testing.** Before placing any concrete, a testing laboratory selected by the ENGINEER shall prepare a trial batch of each class of structural concrete, based on the preliminary concrete mixes submitted by the CONTRACTOR. During the trial batch the aggregate proportions may be adjusted by the testing laboratory using the two coarse aggregate size ranges to obtain the required properties. If one size range produces an acceptable mix, a second size range need not be used. Such adjustments will be considered refinements to the mix design and will not be the basis for extra compensation to the CONTRACTOR. Concrete shall conform to the requirements of this Section whether the aggregate proportions are from the CONTRACTOR's preliminary mix design or whether the proportions have been adjusted during the trial batch process. The trial batch shall be prepared using the aggregates, cement, and admixture proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain 3 drying shrinkage, and 6 compression test specimens from each batch.
 2. **Historical Concrete Testing.** For shrinkage testing [[as well as ASR expansion testing]] requirements, the CONTRACTOR may propose the use of historical test results on these tests provided that all of the following conditions are met:
 - a. The test results are no more than 6-months old from the project Notice-to-Proceed date.

b. The mix design used in the proposed historical tests has the same characteristics, as described below, as the mix design proposed for use on the project:

- 1) The type and quantity of cement used in the historical tested mix, is the same as that of the proposed mix design.
- 2) The quantity and source location of the coarse and fine aggregate used in the historical tested mix is the same as that of the proposed mix design. In addition, the aggregate used in the historical tests must be screened to the same gradations as that proposed for the project mix design.
- 3) The type and quantity of cementations substitutes (fly ash or slag or other approved substitute) used in the historical tested mix, is the same as that of the proposed mix design.
- 4) The water to cement ratio of the historical tested mix is within +/- 5% of the proposed water to cement ratio.
- 5) The air content of the historical tested mix is within 1% of the proposed air content (for example: for a proposed air content of 6% in the proposed mix design, the historical air content must be in the range of 5 to 7%.)
- 6) The same additives, including water reducing additives, that were used in the historical batch test results are being proposed for the new concrete mix design, and the proportions of those additives used in the historical mix design are within +/- 5% of that of the proposed project mix design.

B. **Compressive Strength Testing.** The determination of compressive strength will be made by testing 6-inch diameter by 12-inch high cylinders; made, cured, and tested in accordance with ASTM C 192 - Practice for Making and Curing Concrete Test Specimens in the Laboratory and ASTM C 39. Three compression test cylinders will be tested at 7 Days and 3 at 28 Days. The average compressive strength for the 3 cylinders tested at 28 Days for any given trial batch shall not be less than 125 percent of the indicated compressive strength.

C. **Sieve Analyses.** A sieve analysis of the combined aggregate for each trial batch shall be performed according to the requirements of ASTM C 136 – Method for Sieve Analysis of Fine and Coarse Aggregates. Values shall be given for percent passing each sieve.

2.8 SHRINKAGE LIMITATION FOR STRUCTURAL CONCRETE

A. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21 Day drying age or at 28 Day drying age shall be 0.036 percent or 0.042 percent, respectively. Standard deviation will not be considered. The CONTRACTOR shall only use a mix design for construction that has first met the trial batch shrinkage requirements. Shrinkage limitations apply only to structural concrete.

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

- C. If the required shrinkage limitation is not met during construction, the CONTRACTOR shall take any or all of the following actions to reestablish compliance. These actions may include changing the source of aggregates, cement and/or admixtures; reducing water/cement ratio; washing of coarse and/or fine aggregate to reduce fines; increasing the number of construction joints; modifying the curing requirements; or other actions to minimize shrinkage or the effects of shrinkage.

2.9 MEASUREMENT OF CEMENT AND AGGREGATE

- A. The amount of cement and of each separate size of aggregate entering into each batch of concrete shall be determined by direct weighing equipment furnished by the CONTRACTOR and acceptable to the ENGINEER. Weighing tolerances for the materials shall be a maximum of that given below.

Material	Percent of Total Weight
Cement	1
Aggregates	3
Admixtures	3

2.10 MEASUREMENT OF WATER

- A. The quantity of water entering the mixer shall be measured by a suitable water meter or other measuring device of a type acceptable to the ENGINEER and capable of measuring the water in variable amounts within a tolerance of one percent. The water feed control mechanism shall be capable of being locked in position so as to deliver constantly any required amount of water to each batch of concrete. A positive quick-acting valve shall be used for a cut-off in the water line to the mixer. The operating mechanism shall prevent leakage when the valves are closed.

2.11 READY-MIXED CONCRETE

- A. At the CONTRACTOR'S option, ready-mixed concrete may be used if it meets the requirements as to materials, batching, mixing, transporting, and placing indicated herein and is in accordance with ASTM C 94, including the following supplementary requirements.
- B. Ready-mixed concrete shall be delivered to the WORK, and discharge shall be completed within one hour after the addition of the cement to the aggregates or before the drum has been revolved 250 revolutions, whichever occurs first.
- C. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter shall be the resettable, recording type and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.
- D. Each batch of concrete shall be mixed in a truck mixer for not less than 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the

equipment as agitating speed. Materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.

- E. Truck mixers and their operation shall be such that the concrete throughout the mixed batch as discharged is within acceptable limits of uniformity with respect to consistency, mix, and grading. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than one-inch when the required slump is 3-inches or less, or if they differ by more than 2-inches when the required slump is more than 3-inches, the mixer shall not be used on the WORK unless the causative condition is corrected and satisfactory performance is verified by additional slump tests. Mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit, and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.
- F. Each batch of ready-mixed concrete delivered to the Site shall be accompanied by a delivery ticket that is furnished to the ENGINEER in accordance with the Paragraph above entitled "Delivery Tickets."
- G. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the ENGINEER.

PART 3 -- EXECUTION

3.1 PROPORTIONING AND MIXING

- A. **Proportioning:** Proportioning of the mix shall conform to ACI 301.
- B. **Mixing:** Mixing shall conform to ACI 301.
- C. **Slump:** Slumps shall be as indicated.
- D. **Retempering:** Retempering of concrete or mortar that has partially hardened shall not be permitted.

3.2 PREPARATION OF SURFACES FOR CONCRETING

- A. **General:** Earth surfaces shall be thoroughly wetted by sprinkling prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon. The surface shall be free from standing water, mud, and debris at the time of placing concrete.
- B. **Vapor Retarder Sheet**
 - 1. Sheet shall be installed under on-grade building floor slabs of occupiable (non-hydraulic) structures and at other locations indicated.

2. Sand base shall be at least 2-inches thick within the foundation line after moistening and compaction by mechanical means. Sand surface shall be flat and level within a tolerance of plus zero inches to minus 3/4-inch.
 3. Place, protect, and repair defects in sheet according to ASTM E 1643 – Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs, and the manufacturer's written instructions. Seams shall be lapped and sealed in accordance with ASTM E 1643.
 4. Granular material above the sheet shall be moistened and compacted to 2-inches thickness within the same flatness criteria as the sand base.
- C. **Joints in Concrete:** Construction joints are defined as concrete surfaces upon which or against which concrete is to be placed but placement of concrete has been stopped or interrupted and the ENGINEER has determined that the new concrete cannot be incorporated integrally with the concrete previously placed. The surfaces of horizontal joints shall be given a compacted, roughened surface for good bonding. Except where the Drawings call for joint surfaces to be coated, the joint surfaces shall be cleaned of laitance, loose or defective concrete, foreign material, and be roughened to a minimum 1/4-inch amplitude. Such cleaning and roughening shall be accomplished by hydroblasting or sandblasting (exposing aggregate) followed by thorough washing. Pools of water shall be removed from the surface of construction joints before the new concrete is placed.
- D. **Placing Interruptions:** When placing of concrete is to be interrupted long enough for the concrete to take a set, the working face shall be given a shape by the use of forms or other means that will secure proper union with subsequent WORK; provided that construction joints shall be made only where acceptable to the ENGINEER.
- E. **Embedded Items:** No concrete shall be placed until formwork, installation of parts to be embedded, reinforcement steel, and preparation of surfaces involved in the placing have been completed and accepted by the ENGINEER at least 4 hours before placement of concrete. Surfaces of forms and embedded items that have become encrusted with dried grout from previous usage shall be cleaned before the surrounding or adjacent concrete is placed.
- F. Inserts or other embedded items shall conform to the requirements herein.
- G. Reinforcement, anchor bolts, sleeves, inserts, and similar items shall be set and secured in the forms at locations indicated on the Drawings or shown by Shop Drawings and shall be acceptable to the ENGINEER before any concrete is placed. Accuracy of placement is the responsibility of the CONTRACTOR.
- H. **Casting New Concrete Against Old:** Where concrete is to be cast against old concrete (defined as any concrete which is greater than 60 Days old), the surface of the old concrete shall be thoroughly cleaned and roughened by hydroblasting or sandblasting to expose aggregate. The joint surface shall be coated with an epoxy bonding agent unless determined otherwise by the ENGINEER. This provision shall not apply to joints where waterstop is provided.

- I. No concrete shall be placed in any structure until water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes or other means, and carried out of the forms, clear of the WORK. No concrete shall be deposited underwater nor shall the CONTRACTOR allow still water to rise on any concrete until the concrete has attained its initial set. Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as will injure the surface finish of the concrete. Pumping or other necessary dewatering operations for removing ground water, if required, shall be subject to review by the ENGINEER.
- J. **Corrosion Protection:** Pipe, conduit, dowels, and other ferrous items required to be embedded in concrete construction shall be so positioned and supported prior to placement of concrete that there will be a minimum of 2-inches clearance between said items and any part of the concrete reinforcement. Securing such items in position by wiring or welding them to the reinforcement will not be permitted.
- K. Openings for pipes, inserts for pipe hangers and brackets, and anchors shall, where practicable, be provided during the placing of concrete.
- L. Anchor bolts shall be accurately set and shall be maintained in position by templates while embedded in concrete.
- M. **Cleaning:** The surfaces of metalwork to be in contact with concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed.

3.3 HANDLING, TRANSPORTING, AND PLACING

- A. **General:** Placing of concrete shall conform to the applicable portions of ACI 301 and the requirements of this Section. No aluminum materials shall be used in conveying any concrete.
- B. **Non-Conforming WORK or Materials:** Concrete which during or before placing is found not to conform to the requirements indicated herein shall be rejected and immediately removed from the WORK. Concrete that is not placed in accordance with these requirements or which is of inferior quality shall be removed and replaced.
- C. **Unauthorized Placement:** No concrete shall be placed except in the presence of a duly authorized representative of the ENGINEER. The CONTRACTOR shall notify the ENGINEER in writing at least 24 hours in advance of placement of any concrete.
- D. **Placement in Wall and Column Forms:** Concrete shall not be dropped through reinforcement steel or into any deep form, nor shall concrete be placed in any form in such a manner as to leave accumulation of mortar on the form surfaces above the placed concrete. In such cases, means such as hoppers and, if necessary, vertical ducts of canvas, rubber, or metal shall be used for placing concrete in the forms in a manner that it may reach the place of final deposit without separation. In no case shall the free fall of concrete below the ends of ducts, chutes, or buggies exceed 4-feet in walls and 8-feet in columns. Concrete shall be uniformly distributed during the process of depositing and in no case after depositing shall any portion be displaced in the forms more than 6-feet in horizontal direction. Concrete in wall forms shall be deposited in uniform horizontal layers not deeper than 2-feet; and care shall be taken to avoid

inclined layers or inclined construction joints except where such are required for sloping members. Each layer shall be placed while the previous layer is still soft. The rate of placing concrete in wall forms shall not exceed 5-feet of vertical rise per hour. Sufficient illumination shall be provided in the interior of forms so that the concrete at the places of deposit is visible from the deck or runway.

- E. **Conveyor Belts and Chutes:** Ends of chutes, hopper gates, and other points of concrete discharge throughout the CONTRACTOR's conveying, hoisting, and placing system shall be designed and arranged so that concrete passing from them will not fall separated into whatever receptacle immediately receives it. Conveyor belts, if used, shall be of a type acceptable to the ENGINEER. Chutes longer than 50-feet will not be permitted. Minimum slopes of chutes shall be such that concrete of the indicated consistency will readily flow in them. If a conveyor belt is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt will be wasted. Conveyor belts and chutes shall be covered.
- F. **Placement in Slabs:** Concrete placement in sloping slabs shall proceed uniformly from the bottom of the slab to the top for the full width of the placement. As the WORK progresses, the concrete shall be vibrated and carefully worked around the slab reinforcement, and the surface of the slab shall be screeded in an up-slope direction.
- G. **Temperature of Concrete:** The temperature of concrete when it is being placed shall be not more than 90 degrees F nor less than 50 degrees F. For sections less than 12-inches thick the temperature of concrete when placed shall be not less than 55 degrees.
1. If required by ENGINEER, CONTRACTOR shall submit detailed procedures for production, transportation, placement, protection, curing, and temperature monitoring of concrete during hot or cold weather. The submittal shall include procedures to be implemented upon abrupt changes in weather conditions or equipment failures.
 2. CONTRACTOR shall not be entitled to additional compensation for satisfying the hot weather placement or the cold weather placement requirements below.
- H. **Hot Weather Placement**
1. If the temperature of the concrete is 85 degrees F or greater, the time between introducing the cement into the aggregates and discharge shall not exceed 45 minutes.
 2. If concrete is placed when the weather is such that the temperature of the concrete would exceed 90 degrees F, CONTRACTOR shall employ effective means such as precooling of aggregates and using ice as mixing water or placing at night as necessary to maintain the temperature of the concrete below 90 degrees F as it is placed.
 3. During the curing period, the maximum temperature decrease measured at the surface of the concrete shall not exceed 50 degrees F in 24 hours nor 5 degrees F in one hour.
- I. **Cold Weather Placement**

1. Placement of concrete shall conform to ACI 306.1 - Cold Weather Concreting, and the following.
2. Remove snow, ice, and frost from the surfaces, including reinforcement, against which concrete is to be placed. Before beginning concrete placement, thaw the subgrade to a minimum depth of 6-inches. Reinforcement and embedded items shall be warmed to above 32 degrees F prior to concrete placement.
3. Maintain the concrete temperature above 50 degrees F for at least 72 hours after placement.
4. Concrete ingredients shall not be heated more than necessary to prevent the temperature of the mixed concrete, as placed, from falling below the minimum temperature criterion.

3.4 PUMPING OF CONCRETE

- A. **General:** If the pumped concrete does not produce satisfactory end results, the CONTRACTOR shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.
- B. **Pumping Equipment:** The pumping equipment shall have 2 cylinders and be designed to operate with one cylinder in case the other one is not functioning. In lieu of this requirement, the CONTRACTOR may have a standby pump on the Site during pumping.
- C. The minimum diameter of the hose conduits shall be in accordance with ACI 304.2R – Placing Concrete by Pumping Methods.
- D. Pumping equipment and hose conduits that are not functioning properly shall be replaced.
- E. Aluminum conduits for conveying the concrete shall not be permitted.
- F. **Field Control:** Concrete samples for slump, air content, and test cylinders will be taken at the placement end of the hose.

3.5 ORDER OF PLACING CONCRETE

- A. The order of placing concrete in the WORK shall be acceptable to the ENGINEER. To minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints at the indicated locations. The placing of units shall be done by placing alternate units in a manner such that each unit placed shall have cured at least 5 Days for hydraulic structures and 2 Days for all other structures before the contiguous unit or units are placed, except that the corner sections of vertical walls shall not be placed until the 2 adjacent wall panels have cured at least 10 Days for hydraulic structures and 4 Days for all other structures.
- B. The surface of the concrete shall be level whenever a run of concrete is stopped. For a level, straight joint on the exposed surface of walls, a wood strip at least 3/4-inch thick shall be tacked to the forms on these surfaces. The concrete shall be carried about 1/2-inch above the underside of the strip. About one hour after the concrete is placed, the

strip shall be removed and any irregularities in the edge formed by the strip shall be leveled with a trowel and laitance shall be removed.

3.6 TAMPING AND VIBRATING

- A. As concrete is placed in the forms or in excavations, it shall be thoroughly settled and compacted throughout the entire depth of the layer which is being consolidated into a dense, homogeneous mass, filling all corners and angles, thoroughly embedding the reinforcement, eliminating rock pockets, and bringing only a slight excess of water to the exposed surface of concrete. Vibrators shall be Group 3 per ACI 309 – Consolidation of Concrete, high speed power vibrators (8000 to 12,000 rpm) of an immersion type in sufficient number and with at least one standby unit as required. Group 2 vibrators may be used only at specific locations when accepted by the ENGINEER.
- B. Care shall be used in placing concrete around waterstops. The concrete shall be carefully worked by rodding and vibrating to make sure that air and rock pockets have been eliminated. Where flat-strip type waterstops are placed horizontally, the concrete shall be worked under the waterstops by hand, making sure that air and rock pockets have been eliminated. Concrete surrounding the waterstops shall be given additional vibration over and above that used for adjacent concrete placement to assure complete embedment of the waterstops in the concrete.
- C. Concrete in walls shall be internally vibrated and at the same time rammed, stirred, or worked with suitable appliances, tamping bars, shovels, or forked tools until it completely fills the forms or excavations and closes snugly against each surface. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly. Vibrators shall be provided in sufficient numbers, with standby units as required, to accomplish the required results within 15 minutes after concrete of the prescribed consistency is placed in the forms. The vibrating head shall not contact the surfaces of the forms. Care shall be taken not to vibrate concrete excessively or to work it in any manner that causes segregation of its constituents.

3.7 FINISHING CONCRETE SURFACES

- A. **General:** Surfaces shall be free from fins, bulges, ridges, offsets, honeycombing, or roughness of any kind, and shall present a finished, smooth, continuous hard surface. Allowable deviations from plumb or level and from the alignment, profiles, and dimensions indicated are defined as tolerances and are indicated above. These tolerances are to be distinguished from irregularities in finish as described herein. Aluminum finishing tools shall not be used.
- B. **Formed Surfaces:** No treatment is required after form removal except for curing, repair of Defective concrete, and treatment of surface defects. Where architectural finish is required, it shall be as indicated.
 - 1. Surface holes larger than 1/2-inch in diameter or deeper than 1/4-inch are defined as surface defects in basins and exposed walls.
 - 2. Basins and exposed walls shall be given a smooth finish as indicated below.

3. Basins and exposed walls shall be given 2 coats of cement-based coating as indicated.

C. **Unformed Surfaces:** After proper and adequate vibration and tamping, unformed top surfaces of slabs, floors, walls, and curbs shall be brought to a uniform surface with suitable tools. Immediately after the concrete has been screeded, it shall be treated with a liquid evaporation retardant. The retardant shall be used again after each operation as necessary to prevent drying shrinkage cracks. The classes of finish for unformed concrete surfaces are defined as follows:

1. Finish U1 - Sufficient leveling and screeding to produce an even, uniform surface with surface irregularities not to exceed 3/8-inch. No further special finish is required.
2. Finish U2 - After sufficient stiffening of the screeded concrete, surfaces shall be float finished with wood or metal floats or with a finishing machine using float blades. Excessive floating of surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture will not be permitted. Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities shall not exceed 1/4-inch. Joints and edges shall be tooled where indicated or as determined by the ENGINEER.
3. Finish U3 - After the Finish U2 surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface free from blemishes, ripples, and trowel marks. The finish shall be smooth and free of irregularities.
4. Finish U4 - Trowel the Finish U3 surface to remove local depressions or high points. In addition, the surface shall be given a light broom finish with brooming perpendicular to drainage unless otherwise indicated. The resulting surface shall be rough enough to provide a nonskid finish.
5. Unformed surfaces shall be finished according to the following schedule:

UNFORMED SURFACE FINISH SCHEDULE	
Area	Finish
Grade slabs and foundations to be covered with concrete or fill material	U1
Floors to be covered with grouted tile or topping grout	U2
Water bearing slabs with slopes 10 percent and less	U3
Water bearing slabs with slopes greater than 10 percent	U4

Slabs not water bearing	U4
Slabs to be covered with built-up roofing	U2
Interior slabs and floors to receive architectural finish	U3
Top surface of walls	U3

3.8 CURING AND DAMPPROOFING

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

Surface to be Cured or Dampproofed	Method
Unstripped forms	1
Wall sections with forms removed	6
Construction joints between footings and walls, and between floor slab and columns	2
Encasement and ductbank concrete and thrust blocks	3
Concrete surfaces not specifically indicated in this Paragraph	4
Floor slabs on grade in hydraulic structures	5
Slabs not on grade	6

- B. **Method 1:** Wooden forms shall be wetted immediately after concrete has been placed and shall be kept wet with water until removal. If steel forms are used the exposed concrete surfaces shall be kept continuously wet until the forms are removed. If forms are removed within 7 Days of placing the concrete, curing shall be continued in accordance with Method 6 below.
- C. **Method 2:** The surface shall be covered with burlap mats which shall be kept wet with water for the duration of the curing period, until the concrete in the walls has been placed. No curing compound shall be applied to surfaces cured under Method 2.
- D. **Method 3:** The surface shall be covered with moist earth not less than 4 hours nor more than 24 hours after the concrete is placed. Earthwork operations that may damage the concrete shall not begin until at least 7 Days after placement of concrete.
- E. **Method 4:** The surface shall be sprayed with a liquid curing compound.

1. Compound shall be applied in accordance with the manufacturer's printed instructions at a maximum coverage rate of 200 square feet per gallon and in such a manner as to cover the surface with a uniform film that will seal thoroughly.
2. Where the curing compound method is used, care shall be exercised to avoid damage to the seal during the 7 Day curing period. If the seal is damaged or broken before expiration of the curing period, the break shall be repaired immediately by the application of additional curing compound over the damaged portion.
3. Wherever curing compound has been applied by mistake to surfaces against which concrete subsequently is to be placed and to which it is to adhere, compound shall be entirely removed by wet sandblasting just prior to the placing of new concrete.
4. Curing compound shall be applied as soon as the concrete has hardened enough to prevent marring on unformed surfaces and within 2 hours after removal of forms. Repairs to formed surfaces shall be made within the 2 hour period; provided, however, that any such repairs which cannot be made within the said 2 hour period shall be delayed until after the curing compound has been applied. When repairs are to be made to an area on which curing compound has been applied, the area involved shall first be wet-sandblasted to remove the curing compound.
5. At locations where concrete is placed adjacent to a panel which has been coated with curing compound, the panel shall have curing compound reapplied to an area within 6-feet of the joint and to any other location where the curing membrane has been disturbed.
6. Prior to final acceptance of the WORK, visible traces of curing compound shall be removed in such a manner that does not damage the surface finish.

F. Method 5:

1. Until the concrete surface is covered with curing compound, the entire surface shall be kept damp by applying water using nozzles that atomize the flow so that the surface is not marred or washed. The concrete shall be given a coat of curing compound in accordance with Method 4 above. Not less than one hour nor more than 4 hours after the curing compound has been applied, the surface shall be wetted with water delivered through a fog nozzle, and concrete-curing blankets shall be placed on the slabs. The curing blankets shall be polyethylene sheet, polyethylene-coated waterproof paper sheeting, or polyethylene-coated burlap. The blankets shall be laid with the edges butted together and with the joints between strips sealed with 2-inch wide strips of sealing tape or with edges lapped not less than 3-inches and fastened together with a waterproof cement to form a continuous watertight joint.
2. The curing blankets shall be left in place during the 7 Day curing period and shall not be removed until after concrete for adjacent WORK has been placed. If the curing blankets become torn or otherwise ineffective, the CONTRACTOR shall replace damaged sections. During the first 3 Days of the curing period, no traffic of any nature and no depositing, temporary or otherwise, of any materials shall be permitted on the curing blankets. During the remainder of the curing period, foot traffic and temporary depositing of materials that impose light pressure will be

permitted only on top of plywood sheets 5/8-inch minimum thickness, laid over the curing blanket. The CONTRACTOR shall add water under the curing blanket as often as necessary to maintain concrete surfaces damp.

G. **Method 6:** This method applies to both walls and slabs.

1. The concrete shall be kept continuously wet by the application of water for a minimum period of at least 7 Days beginning immediately after the concrete has reached final set or forms have been removed.
2. Until the concrete surface is covered with the curing medium, the entire surface shall be kept damp by applying water using nozzles that atomize the flow so that the surface is not marred or washed.
3. Heavy curing mats shall be used as a curing medium to retain the moisture during the curing period. The curing medium shall be weighted or otherwise held substantially in contact with the concrete surface to prevent dislodging by wind or any other causes. Edges shall be continuously held in place.
4. The curing blankets and concrete shall be kept continuously wet by the use of sprinklers or other means both during and after normal working hours.
5. Immediately after the application of water has terminated at the end of the curing period, the curing medium shall be removed, the entire concrete surface shall be wetted, and curing compound shall be immediately applied to the entire surface in accordance with Method 4 above.
6. The CONTRACTOR shall dispose of excess water from the curing operation to avoid damage to the WORK.

H. **Dampproofing.** The exterior surfaces of roof slabs to be buried and walls to be backfilled shall be dampproofed as follows

1. Immediately after completion of curing the surface shall be sprayed with a dampproofing agent consisting of an asphalt emulsion. Application shall be in 2 coats. The first coat shall be diluted to one-half strength by the addition of water and shall be sprayed on so as to provide a maximum coverage rate of 100 square feet per gallon of dilute solution. The second coat shall consist of an application of the undiluted material, and shall be sprayed on so as to provide a maximum coverage rate of 100 square feet per gallon.
2. As soon as the material has taken an initial set, the entire area thus coated shall be coated with whitewash. Any formula for mixing the whitewash may be used if it produces a uniformly-coated white surface and remains until placing of the backfill. If the whitewash fails to remain on the surface until the backfill is placed, the CONTRACTOR shall apply additional whitewash.

3.9 PROTECTION

A. The CONTRACTOR shall protect concrete against injury until final acceptance.

- B. Fresh concrete shall be protected from damage due to rain, hail, sleet, or snow. The CONTRACTOR shall provide such protection while the concrete is still plastic and whenever precipitation is imminent or occurring.

3.10 CURING IN COLD WEATHER

- A. Water curing of concrete may be reduced to 6 Days during periods when the mean daily temperature in the vicinity of the Site is less than 40 degrees F; provided that during the prescribed period of water curing, when temperatures are such that concrete surfaces may freeze, water curing is temporarily discontinued.
- B. Concrete cured by an application of curing compound will require no additional protection from freezing if the protection at 50 degrees F for 72 hours is obtained by means of approved insulation in contact with the forms or concrete surfaces; otherwise the concrete shall be protected against freezing temperatures for 72 hours immediately following 72 hours protection at 50 degrees F. Concrete cured by water shall be protected against freezing temperatures for 72 hours immediately following the 72 hours of protection at 50 degrees F.
- C. Discontinuance of protection against freezing temperatures shall be such that the drop in temperature of any portion of the concrete will be gradual and will not exceed 40 degrees F in 24 hours. In the spring, when the mean daily temperature rises above 40 degrees F for more than 3 successive Days, the required 72-hour protection at a temperature not lower than 50 degrees F may be discontinued for as long as the mean daily temperature remains above 40 degrees F; provided, that the concrete shall be protected against freezing temperatures for not less than 48 hours after placement.
- D. Where artificial heat is employed, special care shall be taken to prevent the concrete from drying. Use of unvented heaters will be permitted only when unformed surfaces of concrete adjacent to the heaters are protected for the first 24 hours from an excessive carbon dioxide atmosphere by application of curing compound; provided, that the use of curing compound for such surfaces is otherwise permitted.

3.11 TREATMENT OF SURFACE DEFECTS

- A. As soon as forms are removed, exposed surfaces shall be carefully examined and any irregularities shall be immediately rubbed or ground in a satisfactory manner in order to secure a smooth, uniform, and continuous surface. Plastering or coating of surfaces to be smoothed will not be permitted. No repairs shall be made until after inspection by the ENGINEER. In no case will extensive patching of honeycombed concrete be permitted. Concrete containing minor voids, holes, honeycombing, or similar depression defects shall be repaired as indicated below. Concrete containing extensive voids, holes, honeycombing, or similar depression defects shall be completely removed and replaced. Repairs and replacements shall be performed promptly.
- B. Defective surfaces to be repaired shall be cut back from trueline a minimum depth of 1/2-inch over the entire area. Feathered edges will not be permitted. Where chipping or cutting tools are not required in order to deepen the area properly, the surface shall be prepared for bonding by the removal of laitance and soft material, plus not less than 1/32-inch depth of the surface film from hard portions by means of an efficient sandblast. After cutting and sandblasting, the surface shall be wetted sufficiently in advance of

shooting with shotcrete or with cement mortar so that while the repair material is being applied, the surfaces underneath will remain moist but not so wet as to overcome the suction upon which a good bond depends. The material used for repair shall consist of a mixture of one sack of cement to 3 cubic feet of sand. For exposed walls, the cement shall contain such a proportion of white portland cement as is required to make the color of the patch match the color of the surrounding concrete.

- C. Holes left by tie-rod cones shall be reamed with suitable toothed reamers so as to leave the surfaces of the holes clean and rough. Holes then shall be repaired in an approved manner with dry-packed cement grout. Holes left by form-tying devices having a rectangular cross section and other imperfections having a depth greater than their least surface dimension shall not be reamed but shall be repaired in an approved manner with dry-packed cement grout.
- D. Repairs shall be built up and shaped in such a manner that the completed WORK will conform to the requirements of this Section, as applicable, using approved methods which will not disturb the bond, cause sagging, or cause horizontal fractures. Surfaces of repairs shall receive the same kind and amount of curing treatment as required for the concrete in the repaired section.
- E. Prior to filling any structure with water, cracks shall be "vee'd" as indicated and filled with sealant conforming to the requirements of Section 03290. This repair method shall be done on the water bearing face of members. Prior to backfilling, faces of members in contact with fill which are not covered with a waterproofing membrane shall also have cracks repaired as indicated herein.

3.12 PATCHING HOLES IN CONCRETE

A. Patching Small Holes

- 1. Holes that are less than 12-inches in the least dimension and extend completely through concrete members shall be filled.
- 2. Small holes in members that are water-bearing or in contact with soil or other fill material shall be filled with non-shrink grout. Where a face of the member is exposed to view, the non-shrink grout shall be held back 2-inches from the finished surface. The remaining 2-inches shall then be patched according to the Article above entitled "Treatment of Surface Defects."
- 3. Small holes through other concrete members shall be filled with non-shrink grout, with exposed faces treated as above.

B. Patching Large Holes

- 1. Holes which are larger than 12-inches in the least dimension shall have a keyway chipped into the edge around the opening, unless a formed keyway exists. The holes shall then be filled with concrete as indicated herein.

2. Holes which are larger than 24-inches in the least dimension and which do not have reinforcing steel extending from the existing concrete, shall have reinforcing steel set in grout in drilled holes. The reinforcing added shall match the reinforcing in the existing wall unless indicated otherwise.
3. Large holes in members that are water bearing or in contact with soil or other fill shall have a hydrophilic type waterstop material placed around the perimeter of the hole in accordance with Section 03290 unless there is an existing waterstop in place.

3.13 CARE AND REPAIR OF CONCRETE

- A. The CONTRACTOR shall protect concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance. Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed WORK, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. For items of work for which specific unit prices are established in the contract, concrete is measured to the neat lines or pay limits shown on the drawings, and the volume of concrete is computed to the nearest 0.1 cubic yard. No deduction in volume is made for chamfers, rounded or beveled edges, or for any void or embedded item that is less than 5 cubic feet in volume. Where concrete is placed against the sides or bottom of an excavation without intervening forms, drainfill, or bedding, the volume of concrete required to fill voids resulting from over excavation outside the neat lines or pay limits is included in the measurement for payment where such over excavation is directed by the engineer to remove unsuitable foundation material. However, this payment is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operations, as determined by the engineer

4.2 PAYMENT

- A. Payment for each item of concrete is made at the contract unit price for that item. The payment for concrete will constitute full compensation for completion of the concrete work, including joint fillers, waterstops, metal plates, reinforcing steel, formwork and all other items in Section 03 of the Contract Specifications.

- END OF SECTION -

This Page is Intentionally Blank

SECTION 03 32 00 - JOINTS IN CONCRETE

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide joints in concrete, complete and in place, in accordance with the Contract Documents.
- B. Joints in concrete structures shall be the types defined below and will be permitted only where indicated, unless specifically accepted by the ENGINEER.

1.2 TYPES OF JOINTS

A. **Construction Joints (CJ)**

- 1. These joints are typically identified / abbreviated as "CJ" on the Contract Drawings.
- 2. The purpose of a construction joint is to bond concrete from an earlier pour to that of a later pour, and if in a water-bearing member, prevent water seepage at the joint location.
- 3. When fresh concrete is placed against a hardened concrete surface, the joint between the pours shall be defined as a construction joint.
- 4. Reinforcement typical to the slab exists across the joint.
- 5. Unless otherwise indicated, joints in water-bearing members shall be provided with a waterstop and/or joint sealant groove of the shape indicated.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of General Conditions Section 9 - Submittals.

B. **Shop Drawings**

- 1. Furnish placement drawings showing the location and types of joints for each structure.

C. **Manufacturer's Information and Certificates**

- 1. Furnish manufacturer's information demonstrating compliance of the following with the indicated requirements:
 - a. **Waterstops.** Prior to use of the waterstop material in the field, a sample of a prefabricated (shop made fitting) mitered cross and a tee constructed of each size or shape of material to be used shall be submitted. Samples shall be

prefabricated (shop made fitting) so that the material and workmanship represent the fittings to be provided.

- b. preformed joint filler
 - c. backing rod
 - d. bearing pad
 - e. slip dowels
2. Furnish written certification from the manufacturer, as an integral part of the shipping form, that the material shipped to the Site meets or exceeds the indicated physical property requirements.
 3. Supplier certificates will not be accepted.

D. Samples

1. Prior to production of the material required under this Section, submit qualification samples of waterstops which accurately represent the material being provided.
2. Such samples shall be extruded or molded sections of each size or shape to be installed.
3. The balance of the material to be used shall not be produced until after the ENGINEER has reviewed the qualification samples.

E. Welding Certification

1. Furnish copies of the waterstop welding certification by manufacturer or authorized agent of the manufacturer.
2. Every person who is to be involved with waterstop installation shall be required to have individual certification on file with the ENGINEER, stating that the named individual is certified and trained to install waterstop in accordance with the manufacturer's recommendations and specifications.

1.4 QUALITY CONTROL

A. Waterstops

1. Inspections.

- a. Waterstop field joints shall be subject to inspection, and no such WORK shall be scheduled or started without having made prior arrangements with the ENGINEER for the required inspections.
- b. Provide not less than 24 hours notice for the scheduling of such inspections.

- c. Field joints in waterstops shall be subject to inspection for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects that would reduce the potential resistance of the material to water pressure at any point.
2. **Defects.** The following waterstop defects represent a partial list of defects which shall be grounds for rejection:
- a. Offsets at joints greater than 1/16 inch or 15 percent of material thickness at any point, whichever is less.
 - b. Exterior cracking at the joint due to incomplete bond, which is deeper than 1/16 inch or 15 percent of material thickness at any point, whichever is less.
 - c. Any combination of offset or exterior cracking that will result in a net reduction in the cross-section of the waterstop in excess of 1/16 inch or 15 percent of material thickness at any point, whichever is less.
 - d. Misalignment of the joint which results in misalignment of the waterstop in excess of 1/2 inch in 10 feet.
 - e. Porosity in the welded joint as evidenced by visual inspection.
 - f. Bubbles or inadequate bonding which can be detected with a penknife test. (If, while prodding the entire joint with the point of a penknife, the knife breaks through the outer portion of the weld into a bubble, the joint shall be considered defective.)
 - g. Visible signs of separation when the cooled splice is bent by hand at any sharp angle.
 - h. Evidence of burned material.

B. **Joint Sealant**

1. **Test specimens.**

- a. The CONTRACTOR shall prepare adhesion and cohesion test specimens at intervals of 5 Days while joint sealants are being installed.
- b. The joint sealant material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:
 - 1) Joint sealant specimen shall be prepared between 2 concrete blocks (1-inch by 2-inch by 3-inch).
 - 2) Spacing between the blocks shall be one inch.
 - 3) Coated spacers (2-inch by 1-1/2-inch by 1/2-inch) shall be used to set and hold joint sealant cross-sections of 1/2-inch by 2-inch with a width of one inch.

- 4) The joint sealant shall be cast and cured in accordance with the manufacturer's recommendations, except that the curing period shall be not less than 24 hours.
- 5) Following the curing period, the gap between the blocks shall be widened to 1-1/2 inches, and spacers shall be used to maintain this gap for 24 hours prior to inspection for failure.

1.5 CORRECTION OF DEFECTS

- A. **Waterstops.** If inspections find waterstops to be defective, these joints shall be replaced with material that passes inspection, and faulty material shall be removed from the Site and destroyed.
- B. **Joint Sealant.** The CONTRACTOR shall furnish a 5-year written warranty of the entire joint sealant installation against faulty and/or incompatible materials and workmanship, together with a statement that the CONTRACTOR agrees to repair or replace, to the satisfaction of the OWNER, any defective areas which become evident within the 5-year period.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Joint materials shall be listed as compliant with NSF Standard 61.
- B. Fish Friendly Sealant: Sealants that are required on surfaces that come into contact with fish shall be Tremco Vulkem 921 polyurethane sealant; or approved equal.

2.2 WATERSTOPS

A. PVC Waterstops

1. Waterstops shall be extruded from an elastomeric polyvinyl chloride compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the indicated requirements of this Section.
2. No reclaimed or scrap material shall be used.
3. The CONTRACTOR shall obtain from the waterstop manufacturer and shall furnish to the ENGINEER for review, current test reports and a written certification of the manufacturer that the material to be shipped to the Site meets the physical requirements as outlined in the U.S. Army Corps of Engineers Specification CRD-C572-PVC Waterstops, and those indicated.
4. When tested in accordance with the indicated test standards, the waterstop material shall meet or exceed the following requirements:

Physical Property, Sheet Material	Value	ASTM Std
Tensile Strength-min, psi	2,000	D 638, Type IV
Ultimate Elongation-min, percent	350	D 638, Type IV
Low Temp Brittleness, max degrees F	-35	D 746
Stiffness in Flexure, min, psi	600	D 747
Accelerated Extraction (CRD-C572)		
Tensile Strength-min, psi	1,500	D 638, Type IV
Ultimate Elongation, min, percent	300	D 638, Type IV
Effect of Alkalis (CRD-C572)		
Change in Weight, percent	plus 0.25/minus 0.10	-----
Change in Durometer, Shore A	plus and minus 5	D 2240
Finish Waterstop		
Tensile Strength-min, psi	1,400	D 638, Type IV
Ultimate Elongation, min percent	280	D 638, Type IV

5. Flat strip and Center-Bulb Waterstops

- a. Flat strip and center-bulb waterstops shall be manufactured such that at no place shall the thickness of waterstops, including the center bulb type, be less than 3/8 inch.
- b. The waterstop shall be provided with hog rings installed at 12 inches on centers along the waterstop.
- c. Shapes shall be as indicated, or as acceptable to the ENGINEER.

6. Multi-Rib Waterstops

- a. Multi-rib waterstops shall be as indicated or as acceptable to the ENGINEER.
- b. Prefabricated joint fittings shall be used at intersections of the ribbed-type waterstops.

B. Preformed Hydrophilic Waterstop

1. Hydrophilic (bentonite-free) waterstops shall be **Sika Hydrotite CJ** manufactured by **Sika Corporation, Type NB190** manufactured by **JP Specialties**, or equal.

2. The cross-sectional area of the waterstop shall not be less than 0.5 square inch.
3. Hydrophilic waterstop shall be the type that expands in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.
4. The waterstop shall be manufactured from butyl rubber with hydrophilic properties.
5. The waterstop shall have a delay coating to inhibit initial expansion due to moisture present in fresh concrete.
6. The minimum expansion ratio of modified chloroprene shall be not less than 2-to-1 volumetric change in distilled water at 70 degrees F (21 degrees C).
7. The bonding agent for hydrophilic waterstop shall be the manufacturer's recommended adhesive for wet, rough concrete.

C. Other Waterstops

1. When types of waterstops not listed above are indicated, they shall be subjected to the same requirements as those listed in this Section.

2.3 JOINT SEALANT FOR WATER-BEARING JOINTS

- A. The joint sealant shall be a polyurethane polymer designed for bonding to concrete which is continuously submerged in water.
- B. No material will be accepted which has an unsatisfactory history as to bond or durability when used in the joints of water-retaining structures.
- C. Joint sealant material shall meet the following requirements (73 degrees F and 5 percent R.H.):

Work Life, minutes	45 - 180
Time to Reach 20 Shore A Hardness (at 77 degrees F, 200 gram quantity), max	24 hours
Ultimate Hardness (ASTM D 2240, Shore A)	20 - 45
Tensile Strength (ASTM D 412), min	175 psi
Ultimate Elongation (ASTM D 412), minimum	400 percent
Tear Resistance (Die C, ASTM D 624), pounds per inch of thickness, min	75
Color	Light Gray

- D. Polyurethane joint sealants for waterstop joints in concrete shall conform to the following requirements:

1. Joint sealant shall be 2-part polyurethane with the physical properties of the cured joint sealant conforming to or exceeding the requirements of ASTM C 920 – Elastomeric Joint Sealant, or Federal Specification TT-S-0227 E(3) - Sealing Compound, Elastomeric Type, Multicomponent, for Caulking, Sealing, and Glazing Buildings and Other Structures, for 2-part material, as applicable.
2. For vertical joints and overhead horizontal joints, only "non-sag" compounds shall be used, conforming to the requirements of ASTM C 920, Class 25, Grade NS, or Federal Specification TT-S-0227 E(3), Type II, Class A.
3. For plane horizontal joints, use the self-leveling compounds meeting the requirements of ASTM C 920 Class 25, Grade P, or Federal Specification TT-S-0227 E(3), Type I.
4. For joints subject to either pedestrian or vehicular traffic, a compound providing non-tracking characteristics and having a Shore A hardness range of 35 to 45 shall be used.
5. Primer materials, if recommended by the joint sealant manufacturer, shall conform to the printed recommendations of the manufacturer.

E. Joint Sealant Manufacturers

1. Joint sealants shall be **Sikaflex 2C NS EZ Mix**, as manufactured by **Sika Corporation**, or equal.

2.4 JOINT SEALER FOR NON-WATER-BEARING JOINTS

- A. Joint sealer for non-waterstop joints in concrete shall be a material that is composed of special asphalts or similar materials blended with lubricating and plasticizing agents to form a tough, durable mastic substance that shall:
1. Not contain evaporating solvents, or volatile oils/lubricants;
 2. Strongly adhere to concrete surfaces;
 3. Remain permanently resilient and pliable;
 4. Not be affected by continuous presence of water;
 5. Not in any way contaminate potable water;
 6. Effectively seal the joints against moisture infiltration even when the joints are subjected to movement from expansion and contraction.

2.5 JOINT FILLER

- A. Joint filler for expansion joints in waterholding structures shall be neoprene conforming to ASTM D 1056, Type 2C5-E1.

- B. Joint filler material in other locations shall be of the preformed non-extruding type, constructed of cellular neoprene sponge rubber or polyurethane of firm texture.
- C. Bituminous fiber type will not be accepted.
- D. Non-extruding and resilient-type preformed expansion joint fillers shall conform to the requirements and tests set forth in ASTM D 1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction, for Type I, except as otherwise indicated.
- E. **Neoprene Sponge.** The sponge shall be neoprene, closed-cell, expanded, conforming to ASTM D 1056 - Flexible Cellular Materials - Sponge or Expanded Rubber, Type 2C5-E1.

2.6 BACKING ROD

- A. The backing rod shall be an extruded closed-cell, polyethylene foam rod.
- B. The rod material shall be compatible with the joint sealant material, and shall have a tensile strength of not less than 40 psi and a compression deflection of approximately 25 percent at 8 psi.
- C. The rod shall be 1/8 inch larger in diameter than the joint width except that a one-inch diameter rod shall be used for a 3/4-inch wide joint.

2.7 BEARING PAD

- A. The bearing pad shall be neoprene conforming to ASTM D 2000 - Standard Classification System for Rubber Products in Automotive Applications, BC 420, 40 durometer hardness, unless otherwise indicated.

2.8 SLIP DOWELS

- A. Slip dowels in joints shall be smooth epoxy-coated bars conforming to ASTM A 775 - Epoxy Coated Reinforcing Steel Bars.

2.9 PVC TUBING

- A. PVC tubing in joints shall be SDR 13.5, conforming to ASTM D 2241 - Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

PART 3 -- EXECUTION

3.1 GENERAL - WATERSTOPS

- A. Waterstops shall be embedded in the concrete across joints as indicated.
- B. Waterstops shall be fully continuous for the extent of the joint.
- C. Splices necessary to provide such continuity shall conform to the printed instructions of the waterstop manufacturer.

- D. The CONTRACTOR shall take suitable precautions and provide means to support and protect the waterstops during the progress of the WORK, and shall repair or replace any waterstops damaged during progress of the WORK at no additional cost to the OWNER.
- E. Waterstops shall be stored so as to permit free circulation of air around the waterstop material.
- F. When any waterstop is installed in the concrete on one side of a joint while the other portion of the waterstop remains exposed to the atmosphere for more than 2 Days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of the sun during the entire exposure time until the exposed portion of waterstop is embedded in concrete.

3.2 SPLICES IN PVC WATERSTOPS

- A. Splices in PVC waterstops shall be performed by heat sealing the adjacent waterstop sections in accordance with the manufacturer's printed recommendations.
- B. It is essential that:
 - 1. The material shall not be damaged by heat sealing.
 - 2. The splices shall have a tensile strength of not less than 80 percent of the unspliced material.
 - 3. The continuity of the waterstop ribs and of its tubular center axis shall be maintained.
 - 4. No edge welding will be accepted.
- C. Butt joints of the ends of 2 identical waterstop sections may be made while the material is in the forms.
- D. Other Joints
 - 1. Joints with waterstops involving more than 2 ends to be jointed together, and joints that involve an angle cut, alignment change, or the joining of 2 dissimilar waterstop sections, shall be prefabricated prior to placement in the forms, allowing not less than 24-inch long strips of waterstop material beyond the joint.
 - 2. Upon inspection and approval, such prefabricated waterstop joint assemblies shall be installed in the forms and the ends of the 24-inch strips shall be butt-welded to the straight run portions of waterstop in place in the forms.
- E. Where a centerbulb waterstop intersects and is jointed with a non-centerbulb waterstop, care shall be taken to seal the end of the centerbulb, using additional PVC material if needed.

3.3 JOINT CONSTRUCTION

A. **Setting Waterstops**

1. In order to eliminate faulty installation that may result in joint leakage, particular care shall be taken as to the correct positioning of the waterstops during installation.
2. Adequate provisions shall be made to support and anchor the waterstops during the progress of the WORK and to ensure proper embedment in the concrete.
3. The symmetrical halves of the waterstops shall be equally divided between the concrete pours at the joints.
4. The center axis of the waterstops shall be coincident with the joint openings.
5. Thoroughly work the concrete in the vicinity of joints for maximum density and imperviousness.

B. Waterstop Placement

1. In placing waterstops in the forms, means shall be provided to prevent them from being folded over by the concrete as it is placed.
2. Waterstops shall be held in place with light wire ties on 12-inch centers, which shall be passed through hog rings at the edge of the waterstop and tied to the curtain of reinforcing steel.
3. Horizontal waterstops, with their flat face in a vertical plane, shall be held in place with continuous supports to which the top edge of the waterstop shall be tacked.
4. In placing concrete around horizontal waterstops with their flat face in a horizontal plane, the concrete shall be worked under the waterstops by hand in order to avoid the formation of air and rock pockets.
5. Waterstop in vertical wall joints shall terminate 6 inches from the top of the wall, where such waterstop does not connect with any other waterstop and is not to be connected to a future concrete placement.

C. Joint Location

1. Construction joints and other types of joints shall be provided where indicated.
2. If not indicated, construction joints shall be provided at a 25-foot maximum spacing.
3. Where joints are indicated to be spaced greater than 40 feet apart, additional joints shall be provided to maintain the 25-foot maximum spacing.
4. The location of joints, regardless of type, shall be submitted for acceptance by the ENGINEER.

D. Joint Preparation

1. **Construction Joints:** The surfaces of horizontal joints shall be given a compacted, roughened surface for good bonding. Except where the Drawings call for joint surfaces to be coated, the joint surfaces shall be cleaned of laitance, loose or defective concrete, foreign material, and be roughened to a minimum of 1/4-inch

amplitude. Such cleaning and roughening shall be accomplished by hydroblasting or sandblasting (exposing aggregate) followed by thorough washing. Pools of water shall be removed from the surface of construction joints before the new concrete is placed. The following is also required:

- a. Special care shall be used in preparing concrete surfaces at joints where bonding between 2 sections of concrete is required.
 - b. Unless otherwise indicated, such bonding shall be required at every horizontal joint in walls.
2. **Old Concrete:** Where concrete is to be cast against old concrete (defined as any concrete which is greater than 60 Days old), the surface of the old concrete shall be thoroughly cleaned and roughened by hydroblasting or sandblasting to expose aggregate. The joint surface shall be coated with an epoxy bonding agent unless determined otherwise by the OWNER. This provision shall not apply to joints where waterstop is provided.

E. **Joint Sealant**

1. Crack control joints in water-bearing floor slabs and elsewhere as indicated shall be provided with tapered grooves which shall be filled with a joint sealant, as indicated.
2. The material used to form the tapered grooves shall be left in the grooves until just before the grooves are cleaned and filled with joint sealant.
3. After removing the forms from the grooves, laitance and fins shall be removed, and the grooves shall be sand blasted.
4. The grooves shall be allowed to thoroughly dry, after which they shall be blown out and immediately thereafter, they shall be primed and filled with the construction joint sealant.
5. No joint sealant shall be used without a primer. The primer and sealant shall be placed strictly in accordance with the printed recommendations of the manufacturer, taking special care to properly mix the sealant prior to application.
6. The sides of the sealant groove shall not be coated with bond breaker, curing compound, or any other substance which would interfere with proper bonding of the joint sealant.
7. Care shall be used to completely fill the sealant grooves.
8. The joint sealant shall be installed by a competent waterproofing specialty contractor with a successful record of performance in similar installations.
9. The joint sealant shall achieve final cure at least 7 Days before the structure is filled with water.
10. **Mixing**

- a. Catalyst-cured, 2-part materials shall be thoroughly and uniformly mixed, and special care shall be taken to properly mix the sealer before its application.
- b. Before any sealer is placed, the CONTRACTOR shall arrange to have workers performing the WORK carefully instructed on the proper method of mixing and application by a representative of the joint sealant manufacturer.

11. Failure to Cure

- a. Any joint sealant that fails to fully and properly cure after the manufacturer's recommended curing time for the conditions of the WORK shall be completely removed, and the groove shall be thoroughly sandblasted to remove traces of the uncured or partially cured sealant and primer.
- b. The groove shall be re-sealed with the indicated joint sealant.
- c. Costs of such removal, joint treatment, re-sealing, and appurtenant WORK shall be the CONTRACTOR's responsibility as part of the WORK. ■

F. Hydrophilic Waterstop

1. Where a hydrophilic waterstop is indicated, it shall be installed in accordance with the manufacturer's instructions and recommendations except as may be modified in this Section.
2. When requested by the ENGINEER, the CONTRACTOR shall arrange for the manufacturer to furnish technical assistance in the field.
3. Hydrophilic waterstop shall only be used where complete confinement by concrete is provided.
4. Hydrophilic waterstop shall not be used in expansion or contraction joints nor in the first 6 inches of a non-intersecting joint.
5. **Location**
 - a. The hydrophilic waterstop shall be located as near as possible to the center of the joint, and it shall be continuous around the entire joint.
 - b. The minimum distance from the edge of the waterstop to the face of the member shall be 5 inches.
6. **Placement**
 - a. Where the thickness of the concrete member to be placed on the hydrophilic waterstop is less than 12 inches, the waterstop shall be placed in grooves formed or ground into the concrete.
 - b. The groove shall be at least 3/4-inch-deep and 1-1/4 inches wide.
 - c. When placed in the groove, the minimum distance from the edge of the waterstop to the face of the member shall be 2-1/2 inches.

7. Where a hydrophilic waterstop is used in combination with PVC waterstop, the hydrophilic waterstop shall overlap the PVC waterstop for a minimum of 6 inches and shall be adhered to PVC waterstop by a single component water-swelling sealant as recommended by the manufacturer.
8. The hydrophilic waterstop shall not be installed where the air temperature falls below the manufacturer's recommended range.
9. **Preparation**
 - a. The concrete surface under the hydrophilic waterstop shall be smooth and uniform, and the concrete shall be ground smooth if needed.
 - b. Alternatively, the hydrophilic waterstop shall be bonded to the surface using an epoxy grout that completely fills voids and irregularities beneath the waterstop material.
 - c. Prior to installation, the concrete surface shall be wire brushed to remove any laitance or other materials that may interfere with the bonding of epoxy.
10. **Securing**
 - a. The hydrophilic waterstop shall be secured in place with concrete nails and washers at 12-inch maximum spacing.
 - b. The above requirement shall be in addition to the adhesive recommended by the manufacturer.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as incidental to Section 03 30 00 Cast-in-Place Concrete. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

- A. Payment shall be made in accordance with Section 03 30 00 – Cast-in-Place Concrete.

- END OF SECTION -

This Page Intentionally Left Blank

SECTION 03 60 00 – GROUT

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide grout, complete and in place, in accordance with the Contract Documents
- B. **Grout Types.** The following types of grout are covered in this Section:
 - 1. Cement Grout
 - 2. Non-Shrink Grout - Class I (cement-based)
 - 3. Non-Shrink Grout - Class II (cement-based)
 - 4. Topping Grout and Concrete / Grout Fill

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with General Conditions Section 9 - Submittals.
 - 1. Certified testing lab reports for tests indicated herein.
 - 2. Test results and service report from the field tests and the demonstration and training session verifying the requirements indicated herein.
 - 3. Certification that grouts used on the project contain no chlorides or other chemicals that cause corrosion.
 - 4. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, curing, and appropriate uses for each type of grout used in the WORK, and location of use. ICBO/ES report shall be submitted for epoxy anchor grout for adhesive anchors.
 - 5. Manufacturer's certification that its non-shrink grout does not contain aluminum, zinc, or magnesium powders as a method of expansion.
 - 6. Submit manufacturer's written warranty as indicated herein.
 - 7. Name and telephone number of grout manufacturer's representative who will give on-Site service. The representative shall have at least one year of experience with the indicated grouts.

1.3 QUALITY CONTROL

- A. **Field Tests**

1. Compression test specimens will be taken from the first placement of each type of grout, and at intervals thereafter selected by the ENGINEER. The specimens will be made by the ENGINEER or its representative.
2. Compression tests and fabrication of specimens for cement grout and cement based non-shrink grout will be performed in accordance with ASTM C 1107 - Packaged Dry, Hydraulic-Cement Grout (Nonshrink), at intervals during construction selected by the ENGINEER. A set of 3 specimens will be made for testing at 7 Days, 28 Days, and each additional time period as appropriate.
3. Compression tests and fabrication of specimens for topping grout and concrete/grout fill will be performed in accordance with Section 03 30 00 - Cast-in-Place Concrete, at intervals during construction selected by the ENGINEER.
4. The cost of laboratory tests on grout will be paid by the CONTRACTOR. In such case of defectiveness, the CONTRACTOR shall pay for the tests, removal and replacement of Defective Work, and re-testing, all as part of the WORK.
5. The CONTRACTOR coordinate all testing with the OWNER to allow for observation of collection of specimens.

B. **Construction Tolerances:** Construction tolerances shall be as indicated in Section 03 30 00 - Cast-in-Place Concrete, unless indicated otherwise.

1.4 SPECIAL CORRECTION OF DEFECTS PROVISIONS

A. **Manufacturer's Warranty**

1. Furnish one year warranty for WORK provided under this section.
2. Manufacturer's warranty shall not contain a disclaimer limiting responsibility to the purchase price of products or materials.

PART 2 -- PRODUCTS

2.1 APPLICATION

A. Unless indicated otherwise, grouts shall be provided as listed below whether indicated on the Drawings or not.

Application	Type of Grout
Anchor bolts and reinforcing steel required to be set in grout in which the average working or operating temperature will be over 100 degrees F or in high fire risk areas.	Non-Shrink - Class I
Storage tanks and other non-motorized equipment and machinery under 30 horsepower	Non-Shrink - Class I

Filling blockout spaces for embedded items such as railing posts, gate guide frames, etc.	Non-Shrink - Class I (Class II where placement time exceeds 20 min.)
Toppings and concrete/grout fill greater than 3-inches thick	Structural Concrete per 03 30 00
Surface repairs	Cement Grout
Repair of holes and defects in concrete members which are water bearing or in contact with soil or other fill materials	Non-Shrink - Class II
Any application not listed above, where grout is indicated	Non-Shrink Class I, unless specifically indicated otherwise

2.2 CEMENT GROUT

- A. Cement grout shall be composed of one part cement, 3 parts sand, and the minimum amount of water necessary to obtain the desired consistency. Where needed to match the color of adjacent concrete, white Portland cement shall be blended with regular cement as needed. The minimum compressive strength at 28 Days shall be 4,000 psi.
- B. Cement grout materials shall be as indicated in Section 03 30 00 - Cast-in-Place Concrete.

2.3 NON-SHRINK GROUTS (Cement-based)

A. General

1. Cement-based non-shrink grout shall be a prepackaged, inorganic, fluid, non-gas liberating, non-metallic, cement type grout requiring only the addition of water. Cement from kilns burning metal-rich hazardous waste fuel shall not be used.
2. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each class of non-shrink grout shall be as recommended by the manufacturer for the particular application.
3. Grout shall not contain chlorides or additives that may contribute to corrosion.
4. Grout shall be formulated to be used at any consistency from fluid to plastic.
5. Cement-based non-shrink grout shall have the following minimum properties when tested at a fluid consistency, at 28 Days:
 - a. Minimum tensile splitting strength of 500 psi per ASTM C 496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.

- b. Minimum flexural strength of 1,000 psi per ASTM C 580 - Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
- c. Minimum bond strength (concrete to grout) of 1,900 psi per modified ASTM C 882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
- d. Grout shall be certified for use in freeze/thaw environments.

B. Class I Non-Shrink Grout

- 1. Class I non-shrink grout shall have a minimum 28 Day compressive strength of 5,000 psi when mixed at a fluid consistency.
- 2. Class I non-shrink grout shall meet the requirements of ASTM C 1107, Grade B or C, when mixed to fluid, flowable, and plastic consistencies.
- 3. Grout shall have a maximum early age height change of 4.0 percent expansion, and shall have no shrinkage (0.0 percent) in accordance with ASTM C 827 – Test Method for Early Volume Change of Cementitious Mixtures. The grout when tested shall not bleed or segregate at maximum allowed water.
- 4. Grout shall have no shrinkage (0.0 percent) and a maximum of 0.3 percent expansion in the hardened state when tested in accordance with ASTM C 1090 - Test Method for Measuring Changes in Height of Cylindrical Specimens from Hydraulic-Cement Grout.
- 5. Furnish certification that the non-shrink property of grout is not based on gas production or gypsum expansion.
- 6. Class I Non-Shrink Grout shall be **MasterFlow 713** by **BASF**, **Five Star Grout** by **Five Star Products**, **SikagROUT 212** by **Sika Corporation**, **L&M CRYSTEX** by **Laticrete**; **Hi-Flow Grout** by **Euclid Chemical Company**, or approved equal.

C. Class II Non-Shrink Grout

- 1. Class II non-shrink grout shall be a high precision, fluid, extended working time grout. The minimum 28-Day compressive strength shall be 7,500 psi, when mixed at a fluid consistency.
- 2. Grout shall have a maximum early age height change of 4.0 percent expansion, and shall have no shrinkage (0.0 percent) in accordance with ASTM C 827.
- 3. Grout shall have no shrinkage (0.0 percent) and a maximum of 0.3 percent expansion in the hardened state when tested in accordance with ASTM C 1090.
- 4. Class II non-shrink grout shall have an extended working time of 30 minutes minimum when mixed to a fluid consistency as defined in ASTM C 827 at temperature extremes of 45 to 90 degrees F in accordance with ASTM C 1107.

5. Class II non-shrink grout shall meet the requirements of ASTM C 1107, Grade B or C when tested using the amount of water needed to achieve fluid consistency per ASTM C 939.
6. The grout when tested shall not bleed or segregate at maximum allowed water content.
7. Provide certification that its non-shrink property is not based on gas production or gypsum expansion.
8. Class II non-shrink grout shall be **MasterFlow 928** by **BASF**, **Five Star Fluid Grout 100** by **Five Star Products**, **L&M CRYSTEX** by **Laticrete**, or approved equal.

2.4 TOPPING GROUT AND CONCRETE/GROUT FILL

- A. Where fill is thicker than 3-inches, structural concrete, as indicated in Section 03 30 00 - Cast-in-Place Concrete, may be used when accepted by the ENGINEER.
- B. Grout for topping of slabs and concrete/grout fill for built-up surfaces of tank, channel, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and be mixed as indicated. Materials and procedures indicated for normal concrete in Section 03 30 00 - Cast-in-Place Concrete, shall apply unless indicated otherwise.
- C. Topping grout and concrete/grout fill shall contain a minimum of 564 pounds of cement per cubic yard with a maximum water cement ratio of 0.45.
- D. Coarse aggregate shall be graded as follows:

U.S. Standard Sieve Size	Percent By Weight Passing
1/2 in	100
3/8 in	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

- E. Final mix design shall be as determined by trial mix design as indicated in Section 03 30 00 - Cast-in-Place Concrete, except that drying shrinkage tests are not required.
- F. Topping grout and concrete grout/fill shall contain air-entraining agent per Section 03 30 00 - Cast-in-Place Concrete.

- G. **Strength:** Minimum compressive strength of topping grout and concrete/grout fill at 28 Days shall be 4,000 psi.

2.5 CURING MATERIALS

- A. Curing materials shall be in accordance with Section 03 30 00 - Cast-in-Place Concrete and as recommended by the manufacturer of prepackaged grouts.

2.6 CONSISTENCY

- A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is defined such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as indicated herein for the particular application.
- B. The slump for topping grout and concrete/grout fill shall be adjusted to match placement and finishing conditions but shall not exceed 4-inches.

2.7 MEASUREMENT OF INGREDIENTS

- A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurements shall not be allowed.
- B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Grout shall be stored in accordance with manufacturer's recommendations.

3.2 GENERAL

- A. CONTRACTOR shall arrange for the manufacturer of prepackaged grouts to provide on-Site technical assistance within 72 hours of request, as part of the WORK.
- B. Grout shall not be placed until base concrete or masonry has attained its design strength, unless authorized otherwise by the ENGINEER.
- C. When cementitious grouts are used on concrete surfaces, the concrete surface shall be saturated with water for 24 hours prior to placement. Upon completion of the saturation period, excess water shall be removed with clean, oil free compressed air prior to grouting. Concrete substrate shall not be wet prior to placement of epoxy grouts.
- D. Surface preparation, curing, and protection of cement grout shall be in accordance with Section 03 30 00 - Cast-in-Place Concrete. The finish of the grout surface shall match that of the adjacent concrete unless otherwise indicated.

- E. Surfaces that will be in contact with grout shall be free of dirt, loose rust, oil, wax, grease, curing compounds, laitance, loose concrete, and other deleterious materials.
- F. Shade the WORK from sunlight for at least 24 hours before and 48 hours after grouting.
- G. Contact the grout manufacturer's representative for assistance on hot and cold weather grouting techniques and precautions if applicable.

3.3 GROUTING PROCEDURES

- A. **General:** Mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.
- B. **Equipment, Tank, and Pipe Supports.** Structural, equipment, tank, and piping support bases shall be grouted, unless indicated otherwise.

- 1. The original concrete shall be blocked out or finished off a sufficient distance below the plate to provide for a minimum one-inch thickness of grout or other thickness if indicated.
- 2. After the base plate has been set in position at the proper elevation by steel wedges or double nuts on the anchor bolts, the space between the bottom of the plate and the original pour of concrete shall be filled with non-shrink-type grout through a headbox of appropriate size. The mixture shall be of a fluid consistency and poured continuously into the space between the plate and the base concrete. Forms for grout shall be tight against retaining surfaces, and joints shall be sealed as recommended by the grout manufacturer to be liquid-tight. Forms shall be coated as recommended by the grout manufacturer for easy form release. Where this method of placement is not practical or where required by the ENGINEER, alternate grouting methods shall be submitted for acceptance by the ENGINEER.
- 3. Concrete equipment pads for equipment bases that will be epoxy-grouted shall be sized so that, when the equipment base is fully grouted, the epoxy grout is stopped not less than 4-inches from the edge of the pad.

C. **Drilled Anchors and Reinforcing Bars**

- 1. General
 - a. Drilled anchors and reinforcing bars shall be installed in strict accordance with the manufacturer's instructions. Holes shall be roughened with a brush on a power drill, and cleaned. Drilled anchors shall not be installed until the concrete has reached the required 28 Day compressive strength. Anchors shall not be loaded until the grout has reached its indicated strength in accordance with the manufacturer's instructions.
 - b. The CONTRACTOR shall identify position of reinforcing steel and other embedded items prior to drilling holes. Care shall be exercised in coring and drilling to avoid damaging existing reinforcing or embedded items. Notify the ENGINEER if reinforcing steel or other embedded items are encountered

during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and communications conduit, and piping.

2. Cement Based Non-Shrink Grout

- a. In places of high temperature or fire hazard, anchor bolts shall be grouted in using cement based non-shrink grout, Class I.
- b. Unless otherwise indicated, embedment shall be sufficient to develop the ultimate tensile strength of the anchor or reinforcing bar per the manufacturer's ICBO/ES report, but shall not be less than 16 diameters for threaded rod or 24 diameters for reinforcing or smooth bars.
- c. When the bolt diameter is one-inch or less, the hole diameter should be a minimum of 2-inches. When the bolt diameter is greater than one-inch, the hole diameter should be at least twice the bolt diameter.
- d. Drilled holes shall be saturated with water for not less than 24 hours before installation of anchor/rod/rebar.
- e. The non-shrink grout should be placed in the holes in a non-sag (trowelable) consistency. The grout should be placed in the holes before the anchor and then the anchor inserted and vibrated to ensure proper coverage.

D. Topping Grout and Concrete / Grout Fill

1. Mechanical, electrical, and finish WORK shall be completed prior to placement of topping or concrete/grout fill. To ensure bonding to the base slab, the base slab shall be given an exposed aggregate finish. Alternatively where accepted by the ENGINEER, the base slab shall be given a roughened textured surface by a close-spaced rake while the surface is green. After curing, high pressure washing shall expose the aggregates and produce not less than a 3/16-inch amplitude roughness. Jackhammers or chipping hammers shall not be used.
2. The minimum thickness of grout topping and concrete/grout fill shall be one-inch. Where the finished surface of concrete/grout fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 3-1/2 inches wide by 1-1/2 inches deep.
3. The base slab shall be thoroughly cleaned and wetted to saturated surface dry (SSD) condition per the International Concrete Repair Institute (ICRI) -- Technical Guide for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays, prior to placing topping and fill. No topping concrete shall be placed until the slab is completely free from standing pools or ponds of water. A thin coat of neat cement grout shall be broomed into the surface of the slab just before topping or fill placement. The neat cement grout shall not be allowed to dry before topping placement. If it does dry, it must be immediately removed using wet stiff brooms and reapplied. The topping and fill shall be compacted by rolling or thorough tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to

be installed shall be screeded by blades attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment manufacturer after the grout is brought to the established grade. Coat surface with evaporation retardant as needed to prevent plastic shrinkage cracks.

4. Topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.
5. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping or fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement, or mixture of dry cement and sand shall be applied to the surface.
6. As soon as topping or fill finishing is completed, coat surface with curing compound. After the topping is set and sufficiently hard in clarifiers and where required by the ENGINEER, the tank shall be filled with sufficient water to cover the entire floor for 14 days.

3.4 CONSOLIDATION

- A. Grout shall be placed in such a manner, for the consistency necessary for each application, to assure that the space to be grouted is completely filled.

3.5 CURING

- A. Cement based grouts shall be cured per Section 03 30 00 - Cast-in-Place Concrete and per the manufacturer's recommendations.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as incidental to Section 03 30 00 Cast-in-Place Concrete. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

- A. Payment shall be made in accordance with Section 03 30 00 – Cast-in-Place Concrete.

- END OF SECTION -

SECTION 03 65 00 – EPOXY RESIN ADHESIVE SYSTEMS

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide epoxy resin adhesives, complete and in place, in accordance with the Contract Documents
- B. **Epoxy Resin Adhesives Types.** The following types of epoxy resin adhesives are covered in this Section:
 - 1. Non-Shrink Epoxy Resin Adhesives
 - 2. Epoxy Anchor Resins for Adhesive Anchors

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with General Conditions Section 9 - Submittals.
 - 1. Certified testing lab reports for tests indicated herein.
 - 2. Test results and service report from the field tests and the demonstration and training session verifying the requirements indicated herein.
 - 3. Certification that resins used on the project contain no chlorides or other chemicals that cause corrosion.
 - 4. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, curing, and appropriate uses for each type of resin used in the WORK, and location of use. ICBO/ES report shall be submitted for epoxy anchor resin for adhesive anchors.
 - 5. Manufacturer's certification that its non-shrink resin does not contain aluminum, zinc, or magnesium powders as a method of expansion.
 - 6. Submit manufacturer's written warranty as indicated herein.
 - 7. Name and telephone number of resin manufacturer's representative who will give on-Site service. The representative shall have at least one year of experience with the indicated resins.

1.3 QUALITY CONTROL

A. **Field Tests**

- 1. Compression test specimens will be taken from the first placement of each type of resin, and at intervals thereafter selected by the ENGINEER. The specimens will be made by the ENGINEER or its representative.

2. Compression tests and fabrication of specimens for epoxy resins will be performed in accordance with ASTM C 579 - Test Methods for Compressive Strength of Chemical-Resistant Mortars and Monolithic Surfacing and Polymer Concretes, Method B, at intervals during construction selected by the ENGINEER. A set of 3 specimens will be made for testing at 7 Days and each earlier time period as appropriate.
 3. The cost of laboratory tests on resin will be paid by the OWNER except where test results show the resin to be defective. In such case, the CONTRACTOR shall pay for the tests, removal and replacement of Defective Work, and re-testing, all as part of the WORK.
 4. The CONTRACTOR shall assist the ENGINEER in obtaining specimens for testing and shall furnish materials necessary for fabricating the test specimens.
- B. **Construction Tolerances:** Construction tolerances shall be as indicated in Section 03 33 00 - Cast-in-Place Concrete, unless indicated otherwise.

1. **Epoxy Anchor Resins for Adhesive Anchors**

- a. Special inspection as recommended by the ICBO/ES report or as required by the building department shall be required for adhesive anchor installations. Cost of special inspection of adhesive anchors will be paid by the OWNER.
- b. Before installing adhesive anchors in the WORK, adhesive anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:
 - 1) Hole drilling procedure, hole preparation and cleaning techniques, adhesive injection technique and dispenser training/maintenance, rebar dowel preparation and installation, and proof loading/torquing.
 - 2) Anchors installed in both the vertical and horizontal positions in a mock-up concrete panel of adequate size and thickness. Anchors shall be tested in tension and shear loading. A minimum of 3 anchors shall be tested for each installation position.
 - 3) Anchors shall be tested at 2 times the published allowable load in tension and in shear as indicated in the ICBO/ES report.
 - 4) If any of the 3 test bolts in any installation position fail to reach the test loads, the installer shall be re-tested with the same procedure. Re-testing is required only for the failed installation position.
 - 5) An installer who has 3 consecutive successful bolt tests in the first or second trial is considered qualified for adhesive anchor installation for this project. The manufacturer's representative shall issue a certificate to the qualified installer, and a copy of the certificate shall be filed with the CONTRACTOR and be submitted to the ENGINEER.

- 6) The test anchor size shall be the largest size adhesive anchor used on the project. The embedment length shall be long enough to develop the allowable steel strength per AISC Manual of Steel Construction.
- 7) Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.
- 8) The certification of each qualified installer shall be available for verification at the Special Inspector's request.
- 9) Defective anchors noted by the Special Inspector shall be replaced and re-installed by the CONTRACTOR without any additional compensation.

1.4 SPECIAL CORRECTION OF DEFECTS PROVISIONS

A. **Manufacturer's Warranty**

1. Furnish one-year warranty for WORK provided under this section.
2. Manufacturer's warranty shall not contain a disclaimer limiting responsibility to the purchase price of products or materials.

PART 2 -- PRODUCTS

2.1 APPLICATION

- A. Unless indicated otherwise, epoxy adhesive resins shall be provided as listed below whether indicated on the Drawings or not.

Application	Type of Epoxy Resins
Anchor bolts and reinforcing steel required to be set in resin that is not in high temperature or high fire risk areas.	Epoxy Anchor Resin
Pumps over 1000 horsepower, unless indicated otherwise	Non-Shrink Epoxy

2.2 NON-SHRINK EPOXY RESIN

- A. Non-shrink epoxy adhesives shall be a flowable, non-shrink, 100 percent solids system. The epoxy resin system shall have 3 components: resin, hardener, and specially blended aggregate, each premeasured and prepackaged. The resin component shall not contain any non-reactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios is not permitted unless specifically recommended by the manufacturer. Manufacturer's instructions shall be printed on each container in which the materials are packaged.

- B. Epoxy resin shall have a maximum early age height change of 4.0 percent expansion, and shall have no shrinkage (0.0 percent) in accordance with ASTM C 827, (modified for epoxy resins by using an indicator ball with a specific gravity between 0.9 and 1.1).
- C. Epoxy resin shall have a negligible (less than 0.0006 in/in) length change after hardening, and a coefficient of thermal expansion less than 0.00003 in/in F when tested according to ASTM C 531 - Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Resins, and Monolithic Surfacing.
- D. The epoxy resin shall develop a minimum compressive strength of 9000 psi in 24 hours and 13,000 psi in seven days when tested in accordance with ASTM C 579, method B.
- E. The mixed epoxy resin shall have a minimum working life of 90 to 120 minutes at 70 degrees F.
- F. The effective bearing area shall be a minimum of 95 percent EBA in accordance with ASTM C 1339 – Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Resins, for bearing area and flow.
- G. The chemical formulation of the epoxy resin shall be that recommended by the manufacturer for the particular application. Do not reduce aggregate loading or add solvents to increase flowability.
- H. Non-shrink epoxy resin shall have the following minimum properties when tested at 7 Days:
 - 1. Minimum bond strength to concrete of 3000 psi per ASTM C 882 modified.
 - 2. Minimum bond strength to steel of 1700 psi per ASTM C 882 modified.
 - 3. Minimum flexural strength of 2500 psi per ASTM C 580.
 - 4. Minimum tensile strength of 2000 psi per ASTM C 307 -- Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Resins, and Monolithic Surfacing.
- I. Non-shrink epoxy resin shall be **Five Star DP Epoxy Grout** by **Five Star Products, Inc.**, **Masterflow 648** by **BASF**, **Sikadur 42 Grout-Pak** by **Sika Corporation**, or approved equal.

2.3 EPOXY ANCHOR RESIN

- A. Epoxy anchor resin shall conform to ASTM C 881 - Epoxy-Resin-Base Bonding Systems for Concrete, Type IV, Class B & C, Grade 3 with the exception of gel time.
- B. Heat deflection temperature per ASTM D 648 -- Test Method for Deflection Temperature of Plastics Under Flexural Load shall be a minimum 120 degrees F.
- C. Manufacturer shall certify that the epoxy anchor resin will maintain 90 percent of its strength up to a temperature of 125 degrees F.

- D. Resin shall come in a 2 chambered cartridge with a metering system that provides the proper ratio of hardener and resin. The resin shall also come with a static mixer nozzle to thoroughly mix the hardener and resin together.
- E. Epoxy anchor resin shall be capable of being used in submersed applications once cured.
- F. Compressive strength per ASTM D 695 - Test Method for Compressive Properties of Rigid Plastics shall be 10,000 psi minimum.
- G. Whenever possible, overhead anchors subject to vibration, anchors in fire-resistive construction or high fire risk areas, and anchors subject to working or operating temperatures above 100 degrees F shall be cast-in-place anchors. Whenever cast-in-place anchors cannot be used in these applications, use cement based non-shrink resin and oversized holes.
- H. Embedment of adhesive anchors/rebar shall be deep enough to develop the anchor/rebar. Embedment shall not exceed 67 percent of the member depth.
- I. Epoxy anchor resin shall be **HIT-RE 500 V3** by **Hilti**, or approved equal.

2.4 CURING MATERIALS

- A. Curing materials shall be in accordance with recommendations by the manufacturer of prepackaged resins.

2.5 CONSISTENCY

- A. The consistency of resins shall be that necessary to completely fill the space to be resined for the particular application. Dry pack consistency is defined such that the resin is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a resin of that consistency; the type of resin to be used shall be as indicated herein for the particular application.
- B. The slump for topping resin and concrete/resin fill shall be adjusted to match placement and finishing conditions but shall not exceed 4-inches.

2.6 MEASUREMENT OF INGREDIENTS

- A. Measurements for cement resin shall be made accurately by volume using containers. Shovel measurements shall not be allowed.
- B. Prepackaged resins shall have ingredients measured by means recommended by the manufacturer.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Resin shall be stored in accordance with manufacturer's recommendations.

3.2 GENERAL

- A. CONTRACTOR shall arrange for the manufacturer of prepackaged resins to provide on-Site technical assistance within 72 hours of request, as part of the WORK.
- B. Resin shall not be placed until base concrete or masonry has attained its design strength, unless authorized otherwise by the ENGINEER.
- C. Concrete substrate shall not be wet prior to placement of epoxy resins.
- D. The finish of the resin surface shall match that of the adjacent concrete unless otherwise indicated.
- E. Surfaces that will be in contact with resin shall be free of dirt, loose rust, oil, wax, grease, curing compounds, laitance, loose concrete, and other deleterious materials.
- F. Shade the WORK from sunlight for at least 24 hours before and 48 hours after resining.
- G. Contact the resin manufacturer's representative for assistance on hot and cold weather resining techniques and precautions if applicable.

3.3 RESINING PROCEDURES

- A. **General:** Mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged resins shall be done according to the instructions and recommendations of the manufacturer.
- B. **Equipment, Tank, and Pipe Supports.** Structural, equipment, tank, and piping support bases shall be resined, unless indicated otherwise.
 - 1. The original concrete shall be blocked out or finished off a sufficient distance below the plate to provide for a minimum one-inch thickness of resin or other thickness if indicated.
 - 2. After the base plate has been set in position at the proper elevation by steel wedges or double nuts on the anchor bolts, the space between the bottom of the plate and the original pour of concrete shall be filled with non-shrink-type resin through a headbox of appropriate size. The mixture shall be of a fluid consistency and poured continuously into the space between the plate and the base concrete. Forms for resin shall be tight against retaining surfaces, and joints shall be sealed as recommended by the resin manufacturer to be liquid-tight. Forms shall be coated as recommended by the resin manufacturer for easy form release. Where this method of placement is not practical or where required by the ENGINEER, alternate resining methods shall be submitted for acceptance by the ENGINEER.
 - 3. Concrete equipment pads for equipment bases that will be epoxy-resined shall be sized so that, when the equipment base is fully resined, the epoxy resin is stopped not less than 4-inches from the edge of the pad.
- C. **Drilled Anchors and Reinforcing Bars**

1. General

- a. Drilled anchors and reinforcing bars shall be installed in strict accordance with the manufacturer's instructions. Holes shall be roughened with a brush on a power drill, and cleaned. Drilled anchors shall not be installed until the concrete has reached the required 28 Day compressive strength. Anchors shall not be loaded until the resin has reached its indicated strength in accordance with the manufacturer's instructions.
- b. The CONTRACTOR shall identify position of reinforcing steel and other embedded items prior to drilling holes. Care shall be exercised in coring and drilling to avoid damaging existing reinforcing or embedded items. Notify the ENGINEER if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and communications conduit, and piping.

2. Epoxy Adhesive Anchors

- a. Resin shall be proportioned and mixed with automatic equipment.
- b. Unless otherwise indicated, embedment shall be sufficient to develop the ultimate tensile strength of the anchor or reinforcing bar per the manufacturer's ICBO/ES report, but shall not be less than 8 diameters for threaded rod or 12 diameters for reinforcing or smooth bars.
- c. Holes shall be dry.

3.4 CONSOLIDATION

- A. Resin shall be placed in such a manner, for the consistency necessary for each application, to assure that the space to be resined is completely filled.

3.5 CURING

- A. Cement based resins shall be cured per Section 03300 - Cast-in-Place Concrete and per the manufacturer's recommendations.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as incidental to Section 03 30 00 Cast-in-Place Concrete. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

- A. Payment shall be made in accordance with Section 03 30 00 – Cast-in-Place Concrete.

- END OF SECTION -

This Page Intentionally Left Blank

SECTION 05 12 00 - STRUCTURAL STEEL FRAMING

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide structural steel framing and appurtenant metal parts required for permanent connection of the structural steel system, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. References herein to "Building Code" shall mean the Uniform Building Code of the International Conference of Building Officials (ICBO). The edition of the codes adopted as of the date of award of this contract shall apply to the WORK herein.

- B. Federal Specifications and Commercial Standards

AISC	Code of Standard Practice for Steel Buildings and Bridges
AISC	Structural Steel Buildings-Allowable Stress Design and Plastic Design
AISC	Allowable Stress Design Specifications for Structural Joints Using ASTM A325 and A490 Bolts approved by the Research Council on Structural Connections of the Engineering Foundation
ASTM A 36	Structural Steel
ASTM A 53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 307	Carbon Steel Bolts and Studs
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105-ksi Minimum Tensile Strength
ASTM A 500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 501	Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 992	Steel for Structural Shapes for Use in Building Framing
AWS D1.1	Structural Welding Code – Steel

1.3 CONTRACTOR SUBMITTALS

- A. Submit in accordance with General Conditions Section 9 - Submittals.

- B. Shop Drawings shall conform to AISC recommendations and specifications and shall show all holes, etc. required for other work. Drawings shall include complete details showing members and their connections, anchor bolt layouts, schedules for fabrication procedures, and diagrams showing the sequence of erection.
- C. Testing laboratory certifications for shop and field welders shall be submitted in triplicate directly to the ENGINEER with copies to the CONTRACTOR and others as required.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. **Structural steel**

Plates	ASTM A240, Type S31600
Bars and Shapes	ASTM A276, Type S31600
Pipe, Pipe Columns, Bollards	ASTM A 53, Type E or S, Grade B standard weight unless noted otherwise
HSS	ASTM A312, Type S31600

- B. Bolts for connections shall be ASTM A 325, unless indicated otherwise. Bolts used to connect dissimilar metals shall be ASTM A 193 and A 194, Type 316 stainless steel.
- C. Welded anchor studs shall be headed concrete anchor studs (HAS), or deformed bar anchors (DBA), or threaded studs (TAS), as indicated on the Drawings and as supplied by **Nelson Stud Welding Company (Stanley)** or equal.
- D. Structural steel shall be cleaned and coated in accordance with Section 09 96 00 - Protective Coatings.
- E. Steel members in contact with aluminum shall be galvanized per Section 05 50 00 - Miscellaneous Metalwork, unless indicated otherwise.
- F. Structural members shall be furnished full length without splices unless otherwise indicated or approved by the ENGINEER.

2.2 INSPECTION AND TESTING

- A. Shop inspection may be undertaken by the OWNER at its own expense. The CONTRACTOR shall give ample notice to the ENGINEER prior to the beginning of any fabrication so that inspection may be provided. The CONTRACTOR shall furnish facilities for the inspection of materials and workmanship in the shop, and inspectors shall be allowed free access to the necessary parts of the WORK. Inspectors shall have the authority to reject any materials or WORK that does not meet requirements. Inspection at the shop is intended as a means of facilitating the WORK and avoiding

errors, but it is expressly understood that it will in no way relieve the CONTRACTOR from responsibility for proper materials or workmanship under this Specification.

- B. The OWNER may engage inspectors to inspect welded connections and high-strength bolted connections, and to perform tests and prepare test reports.
 - 1. Ten percent of all butt and bevel welds which extend continuously for 24-inches or less may be completely tested in accordance with AWS D1.1, Part E, Radiographic Testing of Welds, Chapter 6. Butt and bevel welds that extend continuously for more than 24-inches will be spot tested at intervals not exceeding 36-inches.
 - 2. Defective welds shall be corrected or redone and retested at the CONTRACTOR's expense and to the satisfaction of the welding inspector.
 - 3. The CONTRACTOR shall test to failure 3 bolts from each heat lot of bolts furnished to the job to verify compliance with this Specification. The testing laboratory shall be approved by the ENGINEER, and test reports shall be furnished to the ENGINEER in accordance with Section 01 33 00. In addition, high-strength bolts shall be inspected using one of the methods set forth in the AISC Specification "Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. The costs for initial testing will be paid by the OWNER. However, the CONTRACTOR shall pay testing costs for any additional testing and investigation on WORK that proves to be defective. The CONTRACTOR shall supply material for testing at no cost to the OWNER and shall assist the ENGINEER in obtaining material for test samples.

PART 3 -- EXECUTION

3.1 MEASUREMENT

- A. The CONTRACTOR shall verify dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of WORK. The CONTRACTOR shall review the Drawings, and any discrepancies shall be reported to the ENGINEER for clarification prior to starting fabrication.

3.2 FABRICATION

- A. Structural steel shall be fabricated in accordance with the Drawings, AISC Specifications, and the Shop Drawings.
- B. Materials shall be properly marked and match-marked for field assembly.
- C. Where finishing is required, assembly shall be completed including bolting and welding of units, before start of finishing operations.

3.3 CONNECTIONS

- A. Shop and field connections shall be bolted or welded as indicated. Connections shall develop full strength of members joined and shall conform to AISC standard connections.

- B. Unless otherwise indicated, welds shall conform to AISC LRFD Specification for Structural Steel Buildings.

3.4 WELDED CONSTRUCTION

- A. The CONTRACTOR shall comply with the current AWS D1.1 Code for procedures, appearance, and quality of welds and welders, and methods used in correcting Defective WORK. Welded architectural metal that is exposed to view shall have welds ground smooth. Shielded metal arc welding method or gas metal arc welding methods shall be used for welding structural steel.
- B. Unless otherwise indicated, butt and bevel welds shall be complete penetration.

3.5 HOLES FOR OTHER WORK

- A. Holes shall be provided as necessary or as indicated for securing other WORK to structural steel framing, and for the passage of other WORK through steel framing members. No torch cut holes will be permitted.

3.6 SHOP PAINT PRIMER

- A. Shop paint primer shall be applied in accordance with Section 09 96 00. Omit shop-applied primer at field weld locations, for the portion of a member to be embedded in concrete, and where galvanizing with no further coating is required.

3.7 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being excessively stressed, deformed, or otherwise damaged.
- B. Structural steel members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. Repair or replace damaged materials or structures as directed.

3.8 ERECTION

- A. The CONTRACTOR shall comply with the AISC Specifications and Code of Standard Practice, and with indicated requirements.
- B. High-strength bolts shall be installed in accordance with the AISC Specification for Structural Joints Using ASTM A 325 Bolts. The connections shall be the friction type, unless indicated otherwise.
- C. Anchor bolts and other connectors required for securing structural steel to in-place WORK and templates and other devices for presetting bolts and other anchors to accurate locations shall be furnished by the CONTRACTOR.

- D. The CONTRACTOR shall be responsible for designing and installing any temporary bracing required for the safe erection of structural steel members.

3.9 SETTING BASES AND BEARING PLATES

- A. Prior to the placement of non-shrink grout beneath base and bearing plates, the bottom surface of the plates shall be cleaned of all bond-reducing materials, and concrete and masonry bearing surface shall also be cleaned of all bond-reducing materials and be roughened to improve bonding.
- B. Loose and attached baseplates and bearing plates for structural members shall be set on wedges, leveling nuts, or other adjustable devices.
- C. Anchor bolts shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its indicated strength.
- D. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure.

3.10 FIELD ASSEMBLY

- A. Structural frames shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before permanently fastening. Bearing surfaces and other surfaces that will be in permanent contact shall be cleaned before assembly. Necessary adjustments to compensate for discrepancies in elevations and alignments shall be performed.
- B. Individual members of the structure shall be leveled and plumbed within AISC tolerances.
- C. Required leveling and plumbing measurements shall be established on the mean operating temperature of the structure.

3.11 MISFITS AT BOLTED CONNECTIONS

- A. Where misfits in bolting are encountered, the ENGINEER shall be immediately notified. The CONTRACTOR shall submit a method to remedy the misfit for review by the ENGINEER. The ENGINEER will determine whether the remedy is acceptable or if the member must be refabricated.
- B. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins.
- C. Correction of misfits is part of the WORK.

3.12 GAS CUTTING

- A. Gas cutting torches shall not be used in the field for correcting fabrication errors in the structural framing, except when approved by the ENGINEER. Gas-cut sections shall be finished equal to a sheared appearance.

3.13 TOUCH-UP PAINTING

- A. Immediately after erection, field welds, bolted connections, and abraded areas shall be cleaned of the shop paint primer. Touch-up paint primer applied by brush or spray shall be the same thickness and material as used for the shop coat. Galvanized surfaces that have been field welded or damaged shall be repaired in accordance with Section 05 50 00.
- B. Finish coating of structural steel shall be as indicated in Section 09 96 00.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured by the pound (lbs) of the various types of structural steel placed.

4.2 PAYMENT

- A. The contract unit price shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the placement of the structural steel as shown on the Construction Drawings, or as designated in Section 05 12 00 – Structural Steel Framing. A description of work is included at the start of this section. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 05 50 00 - MISCELLANEOUS METALWORK

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide miscellaneous metalwork and appurtenances, complete and in place, as indicated in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Federal Specifications

MIL-G-18015 A (3) (Ships) Aluminum Planks. (6063-T6)

MIL-A-907E Antiseize Thread Compound, High Temperature

B. Codes

OSHA 1927.10 Fixed Ladders

C. Commercial Standards

AA-M32C22A41 Aluminum Assn.

AASHTO HS-20 Truck Loading

AISC Manual of Steel Construction

AISI Design of Light Gauge, Cold-Formed Steel Structural Members

ANSI / AWS D1.1 Structural Welding Code - Steel

ANSI / AWS D1.2 Structural Welding Code - Aluminum

ANSI / AWS QC1 Qualification and Certification of Welding Inspectors

ASTM A 36 Carbon Structural Steel

ASTM A 48 Gray Iron Castings

ASTM A 53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 123 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 193 Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service

ASTM A 194	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
ASTM A 307	Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 992	Steel for Structural Shapes for Use in Building Framing

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of General Conditions Section 9 - Submittals.

B. **Shop Drawings**

1. Shop Drawings shall conform to AISC recommendations and specifications, and shall show holes, and the like, as may be required for other parts of the WORK.
2. Shop Drawings shall include complete details of members and connections, anchor bolt layouts, schedules for fabrication procedures, and diagrams for the sequence of erection.
3. Grating
 - a. Submit layout drawings for grating, showing the direction of span, type and depth of grating, size and shape of grating panels, support seat angle and ledger details, and details of grating hold down fasteners.
 - b. Submit load and deflection tables for each style and depth of grating used.
4. Anchors
 - a. Submit an ICBO report listing the ultimate load capacity in tension and shear for each size and type of concrete anchor.
 - b. Submit manufacturer's recommended installation instructions and procedures for adhesive anchors.
 - c. Upon review by the ENGINEER, these instructions shall be followed specifically.
 - d. No substitution for the indicated adhesive anchors will be considered unless accompanied with ICBO report verifying strength and material equivalency, including temperature at which load capacity is reduced to 90 percent of that determined at 75 degrees F.

1.4 QUALITY CONTROL

- A. Weld procedures and welder qualifications shall be available in the CONTRACTOR's field office for review.

- B. Welding shall be inspected by a CONTRACTOR-furnished inspector qualified in accordance with AWS requirements and approved by the ENGINEER.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Steel

Wide Flange Shapes	ASTM A 992
Shapes, Plates, Bars	ASTM A 36
Pipe, Pipe Columns, Bollards	ASTM A 53, Type E or S, Grade B standard weight unless indicated otherwise
HSS	ASTM A 500 Grade B

B. Corrosion Protection

- 1. Unless otherwise indicated, fabricated steel metalwork which will be used in a corrosive environment and/or will be submerged in water or wastewater shall be coated in accordance with the requirements of Section 09 96 00 - Protective Coatings, and shall not be galvanized prior to coating.

C. Stainless Steel

- 1. Other miscellaneous steel metalwork shall be hot-dip galvanized after fabrication.
- 2. Unless otherwise indicated, stainless steel metalwork and bolts shall be fabricated from Type 316 stainless steel.

D. Aluminum

- 1. Unless otherwise indicated, aluminum metalwork shall be fabricated from Alloy 6061-T6.
- 2. Aluminum in contact with concrete, masonry, wood, porous materials, or dissimilar metals shall have contact surfaces coated in accordance with the requirements of Section 09 96 00 - Protective Coatings.

E. Cast Iron

1. Unless otherwise indicated, iron castings shall conform to the requirements of ASTM A 48, Class 50B, or better.

2.2 ALUMINUM RAILINGS

A. **General**

1. Aluminum handrails and railings shall be component systems, complete with anchors, attachments, balusters, brackets, caps, fasteners, gates (swing with self-latching hardware or be removable), posts, sleeves, trim, and any other related items as required or necessary for a complete installation.
2. Gates and removable rail sections shall be complete with hardware such as self-closing hinges, self-latching latches, hasps, and the like.
3. Railings shall conform to Building Code and OSHA requirements, General Industry Occupational Safety and Health Standards (29CFR1910).

B. **Materials.** Materials shall conform to the following requirements:

1. Aluminum
 - a. Aluminum shall be U.S. Alloy 6063-T5 or T6.
 - b. Aluminum pipe rail shall not be less than 1.5-inch diameter Schedule 40 pipe.
2. When in contact with concrete surfaces, protective coating System 108 (Aluminum Metal Isolation), as defined in Section 09 96 00 - Protective Coatings, shall be provided for electrolysis protection.
3. Sleeves shall be of galvanized steel or heavy duty PVC when embedded in concrete.
4. Grout for handrail posts shall consist of an inorganic, non-shrink, non-metallic premixed grout in accordance with the requirements of Section 03 60 00 - Grout.
5. Fasteners, screws, and bolts shall be concealed and shall be fabricated from stainless steel or aluminum.
6. Aluminum welding rods shall be of a type recommended by the aluminum manufacturer for anodized finished products.
7. Kickplates shall be provided on railings and not set in curbs.

C. **Anodized Finish.** Pipe railing systems, including handrails, safety railings, tube caps, and other miscellaneous parts of the rails, shall be provided with a clear anodized finish, AA-M32C22A41.

2.3

2.4 LADDERS

A. **Materials**

1. Ladders which may be partially or wholly submerged or which are located inside a hydraulic structure shall be fabricated entirely of Type 316 stainless steel.
2. Other ladders shall be fabricated from aluminum.

B. **Pop-Up Extension**

1. Every ladder that does not have an exterior handhold shall be equipped with a pop-up extension.
2. The pop-up extension device shall be manufactured of the same material and finish as the ladder, and shall be provided with a telescoping tubular section that locks automatically when fully extended.
3. Upward and downward improvement shall be controlled by stainless steel spring balancing mechanisms.
4. The units shall be completely assembled with fasteners for securing to the ladder rungs in accordance with the manufacturer's instructions.

2.5 METAL GRATING

A. **General**

1. Metal grating shall be of the indicated design, size, and type.
2. Grating shall be supported around an opening by support members.
3. Where grating is supported on concrete, unless otherwise indicated provide embedded support angles that match the grating material and are mitered and welded at their corners.
4. Banding
 - a. The grating shall be completely banded at edges and cutouts.
 - b. The banding material and cross-section shall be equivalent to the bearing bars.
 - c. The banding shall be welded to each cut bearing bar.
5. The grating pieces shall be fastened to each support in two (2) locations.
6. Where grating forms the landing at the top of a stairway, the edge of the grating that forms the top riser shall have an integral non-slip nosing with a width equal to that of the stairway.

7. Where the grating depth is not indicated, provide grating within allowable stress levels and which shall not exceed a deflection of 1/4-inch or the span divided by 180, whichever is less.
8. Design Loading
 - a. For standard duty plank and safety grating, the loading to be used for determining stresses and deflections shall be the uniform live load of the adjacent floor or 100 psf, whichever is greater, or a concentrated load of 600 pounds.
 - b. For heavy duty grating, the loading used for determining stresses and deflections shall be in accordance with AASHTO HS-20.

B. Material

1. Except where indicated otherwise, bar grating shall be fabricated entirely of:
 - a. aluminum
 - 1) Bearing and Banding Bars: Alloy 6061-T6
 - 2) Cross Bars: Alloy 6063-T5
2. Grating that may be partially or wholly submerged shall be fabricated entirely of Type 316 stainless steel.

C. Standard-Duty Grating

1. No single piece of grating shall weigh more than 80 pounds, unless indicated otherwise.
2. Standard duty grating shall be composed of serrated bar grating.
3. Cross bars shall be welded or mechanically locked tightly into position such that there is no movement between the bearing and cross bars.

D. Lugs

1. Lugs shall be a minimum of one inch in length and raised a minimum of 1/2-inch above the surface.
2. The lugs shall be located in a pattern in which the lugs are oriented at 90 degrees from the adjacent lugs in 2 orthogonal directions.
3. The rows of lugs shall be oriented at 45 degrees from the edges of the plates.

E. Where no material is indicated, the plates shall be fabricated from aluminum.

F. Unless indicated otherwise, the minimum plate thickness shall be as required to limit deflection resulting from a live load of 100 psf to 1/4-inch, or the span divided by 240, whichever is less.

2.6 HATCHES

- A. Where access hatches are mounted on a floor slab (including top slabs that are not covered with a roofing membrane) or on a concrete curb, the hatch shall be flush-type as indicated.
- B. Hatches shall be fabricated from aluminum 5086-H34, 6063-T5 or 6061-T6, unless otherwise indicated.
- C. Hatch hardware shall be fabricated from Type 316 stainless steel, and shall be of the gutter-type.
- D. The design live load shall be a minimum of 300 psf, unless indicated otherwise.
- E. Configuration
 - 1. Hatch opening sizes, number and swing direction of door leaves, and locations shall be as indicated.
 - 2. Indicated sizes are for the clear opening.
 - 3. Where the number of leaves is not indicated, openings larger than 42 inches in either direction shall be provided with double-leaf doors.
 - 4. Unless indicated otherwise, hinges shall be located on the longer dimension side.
 - 5. Unless indicated otherwise, ladder hatches shall be a minimum of 30 inches wide by 36 inches long, with the ladder centered on the shorter dimension and the door hinge opposite the ladder.
- F. Door leaves shall be fabricated from a minimum of 1/4-inch thick checkered-pattern plate.
- G. Channel frames shall be fabricated from a minimum 1/4-inch material with an anchor flange around the perimeter.
- H. Hatches shall be provided with an automatic hold-open arm with release handle.
- I. Hatches shall be designed for easy opening from both inside and outside.
- J. Hatches shall be designed to be water-tight and shall be equipped with a joint gutter and a moat-type edge drain.
- K. A minimum 1.5-inch diameter drain connection shall be provided, located by the manufacturer.

2.7 IRON CASTINGS

A. **General**

- 1. Iron castings shall be of uniform quality, free from blowholes, porosity, hard spots, shrinkage, distortion, or other defects.

2. The castings shall be smooth and well cleaned by shotblasting.
 3. Covers and grates shall fit together evenly, such that the cover fits flush with the surrounding finished surface and such that the cover does not rock or rattle when a loading is applied.
 4. Round covers and frames shall be provided with machined bearing surfaces.
- B. **Loads.** Covers and grates with matching frames shall be designed to support the following loadings:
1. Where located within a structure, the design loading shall match that required for the adjacent floor area, or, if no floor loading is indicated, a minimum of 300 pounds per square foot.
 2. Exterior covers and grates shall be designed for AASHTO HS-20 loading unless indicated otherwise.

2.8 MANHOLE RUNGS

- A. **General.** Rungs shall meet ASTM C 478 - Precast Reinforced Concrete Manhole Sections and the following requirements:
1. Rungs shall be spaced not less than 10-inches apart nor more than 14-inches apart, as measured between centerlines of the rungs.
 2. Rungs shall be parallel, level, and uniformly spaced.
 3. The rungs shall be shaped such that a person's foot cannot slide off the end of the rung.
 4. Rungs shall be surfaced to prevent injury from punctures or lacerations, and to prevent snagging of clothing.
 5. The minimum perpendicular clearance between rungs and any obstruction behind the ladder shall be 6 inches.
 6. The minimum width of rungs shall be 14-inches.
- B. Submit certified test results in accordance with ASTM C 497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile, Section 10, for the following loads:
1. The horizontal pull-out load shall be 400 pounds.
 2. The vertical load shall be 800 pounds.
- C. **Material**
1. Rungs shall be fabricated from co-polymer polypropylene that encapsulates a minimum 1/2-inch grade 60 steel reinforcing rod.
 2. The co-polymer polypropylene shall meet ASTM D 4101, Type PP200B33430.

2.9 BOLTS AND ANCHORS

A. Standard Service (Non-Corrosive Application)

1. Unless otherwise indicated, bolts, anchor bolts, washers, and nuts shall be fabricated from carbon steel as indicated, and hot dip galvanized after fabrication.
2. Threads on galvanized bolts and nuts shall be formed with suitable taps and dies such that they retain their normal clearance after hot-dip galvanizing.
3. Except as otherwise indicated, steel for bolt material, anchor bolts, and cap screws shall be in accordance with the following requirements:
 - a. Structural Connections: ASTM A 307, Grade A or B, hot-dip galvanized
 - b. Anchor Bolts: ASTM A 307, Grade A or B, or ASTM A 36, hot-dip galvanized
 - c. High-Strength Bolts, where indicated: ASTM A 325
 - d. Pipe and Equipment Flange Bolts: ASTM A 193, Grade B-7

B. Corrosive Service

1. Bolts, nuts, and washers in the locations listed below shall be fabricated from **III** Type 316 stainless steel as indicated below **I** or as indicated otherwise on the Contract Drawings.
 - a. Buried locations
 - b. Submerged locations
 - c. Locations subject to seasonal or occasional flooding
 - d. Inside hydraulic structures below the top of the structure
 - e. Inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump
 - f. Chemical handling areas
 - g. Inside trenches, containment walls, and curbed areas
 - h. Locations indicated or designated by the ENGINEER to be provided with corrosion resistant steel bolts
2. **Stainless Steel Nuts on SS Bolts.** Unless otherwise indicated, stainless steel bolts, anchor bolts, nuts, and washers shall be fabricated from Type 316 stainless steel, Class 1, conforming to ASTM A 193 for bolts and to ASTM A 194 for nuts.

C. **Medium Pressure Buried Pipe Flange Hardware.** Buried pipe flange bolts and nuts on pipe of Class 275 and greater shall be in accordance with ASTM A193/A194, Grade B7.

D. **Anti-seize Lubricant Coating**

1. Threads on stainless steel bolts shall be protected with an antiseize lubricant suitable for submerged stainless steel bolts, meeting government specification MIL-A-907E.
2. Buried bolts in poorly drained soil shall be coated the same as the buried pipe.
3. Antiseize lubricant shall be classified as acceptable for potable water use by the NSF.
4. Antiseize lubricant shall be "PURE WHITE" by **Anti-Seize Technology**, Franklin Park, IL, 60131, or equal.

E. **Bolt Requirements**

1. The bolt and nut material shall be free-cutting steel.
2. The nuts shall be capable of developing the full strength of the bolts.
3. Threads shall be Coarse Thread Series conforming to the requirements of the American Standard for Screw Threads.
4. Bolts and cap screws shall have hexagon heads and nuts shall be Heavy Hexagon Series.
5. Bolts and nuts shall be installed with washers fabricated from material matching the base material of bolts, except that hardened washers for high-strength bolts shall conform to the requirements of the AISC Specification.
6. Lock washers fabricated from material matching the bolts shall be installed where indicated.
7. The length of each bolt shall be such that the bolt extends at least 1/8-inch beyond the outside face of the nut before tightening, except for anchor bolts which shall be flush with the face of the nut before tightening.

2.10 Drilled Anchors in Concrete and Masonry

A. **General**

1. Unless otherwise indicated, drilled concrete or masonry anchors shall be adhesive anchors.
2. No substitutions will be considered unless accompanied with an ICBO report verifying strength and material equivalency.

3. Expanding type anchors are not permitted unless specifically indicated otherwise in the Contract Documents.

B. Epoxy Anchors

1. Epoxy adhesive anchors are required for drilled anchors for outdoor installations, in submerged, wet, splash, overhead, and corrosive conditions, and for anchoring handrails and reinforcing bars.
2. Epoxy shall be in accordance with the requirements of Section 03 60 00 - Grout.
3. Threaded rod shall be galvanized for general purpose applications and fabricated from Type 316 stainless steel for use in corrosive applications.
4. Epoxy anchors shall not be permitted in areas where the concrete temperature is in excess of 100 degrees F or higher than the limiting temperature recommended by the manufacturer, whichever is lower.
5. Epoxy anchors shall not be used where anchors are subject to vibration or fire.
6. Embedment depth shall be as the manufacturer recommends for the load to be supported.
7. Unless otherwise indicated, glass capsule, polyester resin adhesive anchors will be permitted in locations not included above, and shall be **Hilti HVU2** or equal.
8. Threaded rod shall be fabricated from galvanized steel.

C. Non-Shrink Grouted Anchors

1. Anchors, if indicated or permitted, shall be grouted with a non-shrink cementitious grout in accordance with the manufacturer's recommendations.
2. Embedment depth shall be as the manufacturer recommends for the load to be supported.
3. Non-shrink grout material shall be Class B or C in accordance with Section 03 60 00 - Grout.

D. Expanding-Type Anchors

1. Expanding-type anchors, if indicated or permitted, shall be fabricated from galvanized steel, shall be of the expansion type, and shall be **Redhead Trubolt** anchors, **Hilti Kwik Bolt**, or equal.
2. Lead caulking anchors will not be permitted.
3. Size shall be as indicated.
4. Embedment depth shall be as the manufacturer recommends for the load to be supported.

5. Expansion-type anchors that are to be embedded in grout may be fabricated from steel.
6. Non-embedded buried or submerged anchors shall be fabricated from stainless steel.

PART 3 -- EXECUTION

3.1 FABRICATION AND INSTALLATION REQUIREMENTS

A. Fabrication and Erection

1. Except as otherwise indicated, the fabrication and erection of structural steel shall conform to the requirements of the American Institute of Steel Construction "Manual of Steel Construction."

B. Aluminum Railings

1. Aluminum railing fabrication and installation shall be performed by craftsmen experienced in the fabrication of architectural metalwork.
2. Exposed surfaces shall be free from defects or other surface blemishes.
3. Dimensions and conditions shall be verified in the field.
4. Joints, junctions, miters, and butting sections shall be precision fitted with no gaps occurring between sections, and with surfaces flush and aligned.
5. Electrolysis protection of materials shall be provided.

- C. **Hatch Drains.** Unless otherwise indicated, the CONTRACTOR shall provide a 1/2-inch, galvanized steel drain line to the nearest surface drain location for floor or roof hatches.

3.2 WELDING

A. Methods & Qualifications

1. Welding shall be performed by the metal-arc method or gas-shielded arc method as described in the American Welding Society "Welding Handbook" as supplemented by other pertinent standards of the AWS.
2. The qualification of the welders shall be in accordance with the AWS Standards.

B. Quality

1. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained in order to minimize distortion and for control of dimensions.
2. Weld reinforcement shall be as indicated by the AWS Code.

3. Upon completion of welding, remove weld splatter, flux, slag, and burrs left by attachments.
4. Welds shall be repaired in order to produce a workmanlike appearance, with uniform weld contours and dimensions.
5. Sharp corners of material that is to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.

3.3 GALVANIZING

- A. Structural steel plates, shapes, bars, and fabricated assemblies required to be galvanized shall, after the steel has been thoroughly cleaned of rust and scale, be galvanized in accordance with the requirements of ASTM A 123.
- B. Any galvanized part that becomes warped during the galvanizing operation shall be straightened.
- C. Bolts, anchor bolts, nuts, and similar threaded fasteners, after being properly cleaned, shall be galvanized in accordance with the requirements of ASTM A153.
- D. **Field Repairs**
 1. Field repairs to damaged galvanizing shall be performed by preparing the surface and applying a coating.
 2. Surface preparation shall consist of removing oil, grease, soil, and soluble material by cleaning with water and detergent (SSPC SP1) followed by brush-off blast cleaning (SSPC SP7) over an area extending at least 4 inches into the undamaged area.
 3. The coating shall be applied to at least 3 mils dry film thickness, and shall be **Zinc-Clad XI** by **Sherwin-Williams**, **Galvax** by **Alvin Products**, **Galvilite** by **ZRC Worldwide**, or equal.

3.4 DRILLED ANCHORS

- A. Drilled anchors and reinforcing bars shall be installed in strict accordance with the manufacturer's instructions.
- B. Holes shall be roughened with a brush on a power drill, and then cleaned and dried.
- C. Drilled anchors shall not be installed until the concrete has reached the required 28-day compressive strength.
- D. Adhesive anchors shall not be loaded until the adhesive has reached its indicated strength in accordance with the manufacturer's instructions.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as the square foot (SF) of grating, pounds (LBS) of dam boards and lineal foot (LF) of handrailing including swing gate all of which have been constructed as shown in the Contract Documents.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the placement of miscellaneous metalwork as shown on the Construction Drawings, or as designated in Section 05 50 00 – MISCELLANEOUS METALWORK. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 00 – ELECTRICAL WORK, GENERAL

PART 1 -- GENERAL

1.1 DESCRIPTION OF WORK

- A. The work includes furnishing all materials, labor, and equipment to install complete electrical and control systems as shown on the Drawings and specified herein.
- B. Requirements specified in this section apply to all sections in Division 26. Work specified herein shall be performed as if specified in the individual Sections of these specifications.

1.2 CONFLICTS BETWEEN DRAWINGS AND SPECIFICATIONS

- A. The specifications provide a set of minimum requirements which must be followed with regard to installation and testing electrical systems. In the event of a conflict between the drawings and specifications, the drawings shall supersede. The drawings are considered more detailed and shall be taken as priority.

1.4 COMPLIANCE WITH ELECTRICAL AND SAFETY CODES

- A. Electrical equipment and installation work shall conform to the requirements of the latest National Electrical Code, National Electrical Safety Code and applicable State and local codes. Other standards specified in each Section of these specifications are additionally applicable to the work of this Contract.
- B. Qualifications of Electrical Installer: Installation and termination of field electrical circuits shall be performed by electricians licensed by the State of California. Proof of journeyman licensure shall be submitted for review.
- C. Manufacturers of electrical control panels and enclosures shall be UL 508 certified.

1.5 POWER SOURCES

- A. Contractor is responsible for applying for and obtaining necessary electrical service modifications from the utility, as well as all other electrical permits for the project which may be required. Contractor is also responsible for coordinating with the electric utility for any necessary power outages or primary service work that may be required.
- B. Secondary service power consists of a 240/120VAC, 1-phase, 3-wire system as provided by the step-down transformer provided by the utility.

1.6 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Submit proof of licensure in the State of California for all electricians.

C. Technical Manuals.

D. Record Drawings.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide materials and equipment listed by UL wherever standards have been established by that agency.

B. Equipment Finish:

1. Provide manufacturers' standard finish and color, except where specific color is indicated. Manufacturer's standard colors are subject to OWNER's approval.
2. If manufacturer has no standard color, provide equipment with ANSI No. 61, light gray color.

PART 3 -- EXECUTION

3.1 GENERAL

- A. Contract Drawings are designed to show general locations of equipment and conduit routing. Unless specifically noted on the drawing, CONTRACTOR is responsible for determining final equipment locations, conduit routing, and wiring requirements to avoid conflicts with structures and mechanical equipment and based on approved suppliers' shop drawings, which may have specific wiring requirements not available on the Drawings.
- B. Install work in accordance with these specifications, NESC and NEC, and as required by local and state agencies including OSHA. NEC shall govern where there is conflict between NESC and NEC requirements.
- C. Schedule with OWNER for work requiring power outages. Power outages will be subject to limitation in accordance with OWNER's site operation requirements.

3.2 LOAD BALANCE

- A. Balance electrical loads between phases as nearly as possible on panelboards, motor controls, and other equipment where balancing is required.
- B. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.3 INSTALLATION

- A. Cooperate with other entities engaged in or working near the project. Execute work in a manner not to interfere with other CONTRACTORS or other activities.
- B. Coordinate work with other CONTRACTORS regarding location of equipment so there is no interference between installation or progress of any contractor.
- C. At project completion, clean all equipment to the original finish. Remove all shipping labels.
- D. Test electrical equipment provided and installed, per ANSI/NETA ATS-2017 Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement for all Electrical work shall be made as a lump sum including all conduits, wires, panels and associated items.

4.2 PAYMENT

- A. Payment for all Electrical work shall be made as a lump sum when all conduits, wires, panels and associated items are installed, and power is begin delivered to the cone screen and head gate.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 02 - MICELLANEOUS ELECTRICAL DEVICES

PART 1 -- GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
 - c. ICS 2, Industrial Control Devices and Systems: Controllers, Contactors, and Overload Relays Not More than 2000 volts ac or 750 Volts DC.
 - d. PB 1, Panelboards.
 - e. ST 20, Dry-Type Transformers for General Applications.
 - f. WD 1, General Requirements for Wiring Devices.
 2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)
 3. Institute of Electrical and Electronics Engineers: C2, National Electrical Safety Code (NESC).
 4. Underwriters Laboratories, Inc. (UL):
 - a. 67, Standard for Safety Panelboards.
 - b. 98, Standard for Safety Enclosed and Dead-Front Switches.
 - c. 486E, Standard for Safety for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Safety for Industrial Control Equipment.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings and Manufacturer's Data:
1. Outlet and device boxes.

2. Junction and pull boxes.
3. Wiring devices.
4. Circuit breakers.

1.3 QUALITY ASSURANCE

- A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 OUTLET AND DEVICE BOXES

- A. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.
- B. Cast Metal:
 1. Box: Cast ferrous metal.
 2. Cover: Gasketed, weatherproof, cast ferrous metal, with stainless steel screws.
 3. Hubs: Threaded.
 4. Lugs: Cast Mounting.
- C. Nonmetallic:
 1. Box: PVC.
 2. Cover: PVC, weatherproof, with stainless steel screws.
 3. Manufacturer and Product: Carlon Type FS or FD, with Type E98 or E96 covers.

2.2 JUNCTION AND PULL BOXES

- A. Outlet Boxes Used as Junction or Pull Box: As specified under Article OUTLET AND DEVICE BOXES.
- B. Conduit Bodies Used as Junction Boxes: As specified under Article FITTINGS in Section 16110, RACEWAYS.
- C. Steel Box:
 1. NEMA 250, Types: 1, 3R and 12.
 2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by: OWNER.

3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.

2.3 WIRING DEVICES

A. Switches:

1. NEMA WD 1 and FS W-S-896F/GEN.
2. Industrial grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contacts.
4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
5. Rating: 20 amps, 120/277 volts.
6. Automatic grounding clip and integral grounding terminal on mounting strap.

B. Receptacle, Single and Duplex:

1. NEMA WD 1 and FS W-C-596.
2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
3. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
4. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
5. One-piece mounting strap with integral ground contact (rivetless construction).

C. Receptacle, Ground Fault Circuit Interrupter:

1. Duplex, listed Class A to UL Standard 943, tripping at 5 mA.
2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
3. Size: For 2-inch by 4-inch outlet boxes.
4. Standard Model: NEMA WD 1, with screw terminals and provisions for testing.
5. Feed-Through Model: NEMA WD 1, with feed-through screw terminals and provisions for testing.

2.4 FUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

- A. Quick-make, quick-break, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions.
- B. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- C. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.
- D. Enclosure: NEMA 250, Type as indicated in Part 3 of this Specification, unless otherwise shown.
- E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position.

2.5 NONFUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

- A. NEMA KS 1.
- B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- D. Enclosure: NEMA 250, Type as indicated in Part 3 of this Specification unless otherwise shown.
- E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

2.6 TERMINAL BLOCK (0 TO 600 VOLTS)

- A. UL 486F/GEN and UL 1059.
- B. Size components to allow insertion of necessary wire sizes.
- C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
- D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
- E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
- F. Yoke shall guide all strands of wire into terminal.
- G. Current bar shall ensure vibration-proof connection.
- H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
 2. Capable of jumper installation with no loss of terminal or rail space.
 3. Short-circuiting type for current transformer leads.
- I. Marking system, allowing use of preprinted or field-marked tags.
- 2.7 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)
- A. UL 1561, NEMA ST 20, unless otherwise indicated.
 - B. Self-cooled, two-winding.
 - C. Insulation Class and Temperature Rise: Manufacturer's standard.
 - D. Core and Coil:
 1. Winding conductor shall be copper.
 2. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA.
 3. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.
 - E. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - F. Enclosure:
 1. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated.
 2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
 3. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, non-ventilated.
 4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
 5. Outdoor Transformers: NEMA 250, Type 3R.
 - G. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for three-phase units, 15 to 30 kVA.
 - H. Voltage Taps:
 1. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
 2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

3. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
 4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
- I. Impedance: 4.5 percent minimum on units 75 kVA and larger.
- J. Maximum Sound Level: NEMA ST 20:
1. 40 decibels for 0 to 9 kVA.
 2. 45 decibels for 10 to 50 kVA.
 3. 50 decibels for 51 to 150 kVA.
 4. 55 decibels for 151 to 300 kVA.
 5. 60 decibels for 301 to 500 kVA.
- K. Vibration Isolators:
1. Rated for transformer's weight.
 2. Isolation efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
 3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
 4. 30 kVA and above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

2.8 PANELBOARD AND CIRCUIT BREAKERS

- A. The panelboard shall be Crouse-Hinds XLPB or equivalent rated NEMA 4X, 240/120V, 3-wire, single phase, 18 spaces, and minimum 10kA interrupt current. The panelboard must also be service entrance rated.
1. Manufacturers
 - a. Eaton/Cutler-Hammer/Crouse-Hinds.
 - b. General Electric.
 - c. Siemens.
 - d. Square D
 2. Circuit breakers and panelboard shall be of the same manufacturer.
- B. Molded Case Circuit Breakers: NEMA AB 1, FS W-C-375; Provide bolt-on type circuit breakers with integral thermal and instantaneous magnetic trip in each pole (common trip type). Provide circuit breakers, UL listed as Type HACR, for air conditioning equipment branch circuits. Provide circuit breakers, UL listed as Type

SWD, for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where specified on panelboard schedules and/or the Drawings.]

1. Trip Unit:
2. Instantaneous magnetic trips shall be accessible and adjustable from the front of the breaker on frame size 100 amperes.
3. Trip units shall be interchangeable and adjustable for trip pick up and delay settings on frame size 225 amperes.
4. Breakers sized 400 amperes and higher shall be equipped with solid state trip units with long-time, short-time, instantaneous, and ground fault (LSIG) tripping characteristics.
5. Breakers shall be rigidly mounted, separately removable and independent of trim plates for their support. Breakers shall be bolt on type.
6. Breakers shall be industrial grade with a minimum pole width of 1-inch (25.4 mm) and a minimum height of 5-1/2-inches (139.7 mm). Miniature circuit breakers or breakers having a pole width of 1/2-inch are not acceptable.
7. The minimum symmetrical interrupting rating for molded-case circuit breakers shall be as specified on the panelboard schedule and/or Drawings. Series rated breakers are not acceptable.

C. Bus Hardware

1. Panelboards shall be completely factory assembled and equipped with a main circuit breaker and the type, size and number of branch circuit breakers, arranged and numbered as shown on the attached panel schedule(s). Panelboards shall be fully rated. Series rated panelboards are not acceptable.
2. All multi-pole breakers shall be common trip. Branch circuits shall be arranged using double row construction. Bus sequence shall be ABC top to bottom, left to right for both top and bottom fed panels. Provisions or space for future breakers shall be located at the bottom of the panel and be fully bussed, complete with the necessary mounting hardware. Use at least 100 ampere breaker-connecting bus straps and mounting hardware.
3. Where SPARE is indicated on the panel schedule(s), the specified circuit breaker and 100 ampere (minimum) branch-circuit busing and mounting hardware shall be installed.
4. Where SPACE is indicated on the panel schedule(s), 100 ampere (minimum) branch-circuit busing and mounting hardware shall be installed, ready for future installation of circuit breakers, furnished by others. A minimum of 20 percent spare pole spaces, grouped in multiple of three, shall be provided in each panelboard, for future installation. Provide single pole filler plates in the spaces, as required.
5. A nameplate shall be provided, and located near the top of the front trim on the exterior surface, listing panel type and ratings, as required by UL. Each circuit shall be permanently numbered to agree with the panel schedule, using plastic or metal buttons mounted adjacent to the breaker and secured by rivets or grommets with an engraved or depressed number. Adhesive numbering tape, painted numbers, or use of more than one number per breaker is not acceptable.
6. Main vertical bus bars shall be copper and plated per UL requirements. Bus bars shall be supported by glass-filled polyester-type insulators. Bolts used to connect

current-carrying parts together, shall be accessible for tightening from the front of the panel. Bus bars shall be factory drilled and tapped with spacing arranged to permit breaker interchange, from the front, while the panel is energized.

7. Neutral bus shall be copper, 200 percent rated and insulated from the cabinet and other parts. It shall be rigidly mounted in the panel and shall be provided with a solderless cable connector for each circuit breaker and each space in the panelboard and the main connecting lug(s).
8. A copper equipment ground bus, of sufficient width and length, shall be solidly bolted and grounded to the enclosure at the bottom and shall leave clear space for the bottom cable entries. The bus shall have sufficient termination points in number to agree with branch circuits and spaces. A solderless connector, for No. 2 to No. 4/0 cable size, shall be bolted to the ground bus.
9. Copper bus bars shall be of sufficient size to provide a current density of not more than 1000 amperes per square inch of cross section, and not more than 200 amperes per square inch at bolted connections.
10. Minimum Short Circuit Rating for Bus Bracing: The bus shall be braced for the minimum symmetrical short circuit rating of the panel, as shown on the panel schedule.
11. Provide main bus pressure connectors (main lugs) and separately supported sub-feed pressure connectors (lug landings) where noted. Provide additional bottom raceway space to accommodate pressure connectors and lug landings. In no instance shall the gutter space be less than required by NFPA-70.
12. Pre-installed locking devices shall be provided for locking the main circuit breaker and each branch circuit breaker in the OPEN position, by means of a padlock. Locking devices shall not be removable from the front of the panel with the trim in place. Attachment of the locking device to the panel with adhesives is not acceptable.

D. Drawings

Include drawings numbers for the panelboard schedules. Schedules shall provide the following information:

1. Panelboard Number Name or Label.
2. Panelboard type.
3. Number of phases.
4. Main bus ampacity.
5. Main circuit breaker trip rating.
6. Branch circuit breaker arrangement.
7. Branch circuit breaker trip sizes.
8. Flush or surface mounting.
9. Enclosure type.
10. Service entrance rating requirement (indicate 'Y', if required).
11. Power Metering Requirement (indicate 'Y', if required).
12. Circuit load.

2.9 CONTROL DEVICES

A. PUSHBUTTONS:

Pushbuttons shall be flush head, heavy-duty, with NEMA rating to match enclosure type. The pushbutton operators shall be red for stop functions and black for all other functions. Unless otherwise specified, pushbuttons shall be momentary contact type. Contact blocks shall be NEMA 1CS-2 designation A600 except when switching circuits monitored by programmable controllers or other solid state circuits, contact blocks shall be hermetically sealed, logic-reed type as manufactured by Allen-Bradley, or equal.

B. SELECTOR SWITCHES (AS APPLICABLE):

Selector switches shall be heavy-duty, with NEMA rating to match enclosure type. Unless otherwise specified, selector switches shall have maintained position contacts. Switches shall be provided with contact blocks and number of positions as required to perform the specified operations.

C. INDICATING LIGHTS:

Indicating lights shall be the push-to-test transformer type with LEDs. They shall be heavy-duty, with NEMA rating to match enclosure type. The escutcheon and lens color shall be as specified.

D. CONTROL PANELS:

Unless otherwise specified, control stations indoors shall be NEMA 12. Control panels located outdoors and in wet or corrosive areas shall be stainless steel, NEMA 4X. The pushbuttons shall have protective Hypalon boots. The control panels shall be Allen-Bradley 800 H series, Crouse-Hinds NCS series, or approved equal.

2.9 CONTROL RELAYS

A. LOAD-SWITCHING CONTROL RELAYS:

Control relays used for switching loads (solenoids, actuators, contactors, motor starter coils, etc.) shall be heavy-duty machine tool type. Relays that have contacts used for remote interlocking or for which the switching load is not shown shall also be heavy-duty machine tool type.

Contacts shall, as a minimum, be 4-pole and be field interchangeable to either normally open or normally closed. Relay shall be capable of accepting a 4-pole adder.

AC relays shall have NEMA A600 contact ratings and electrical clearances for up to 600 volts. DC relays shall have NEMA P300 contact ratings and electrical clearances of up to 250 volts.

Relays shall be Allen Bradley, or approved equal.

B. LOGIC LEVEL SWITCHING CONTROL RELAYS:

Control relays used for switching solid-state logic and signal circuits shall be Potter Brumfield series KUP, Schrack Series RA, or equal. Relays shall have a minimum of three SPDT, gold-flashed, fine silver contacts rated 3 amps resistive at 120V AC or 28V DC. Relay shall be plug-in type with heavy-duty, barrier-protected screw terminal sockets and clear polycarbonate dust cover with clip fastener. AC models shall have neon lamp indicator wired in parallel with coil.

C. LATCHING RELAY:

The unit shall be an electrically actuated latching relay or an industrial relay with an electrically operated latching attachment. The latching mechanism shall contain one SET coil and one RESET coil rated for continuous duty on 120 VAC or as otherwise shown. The action of the relay shall be such that it will maintain the last state upon a power failure. The relay contacts rated B300 and hermetically sealed in a glass envelope. They shall be normally open and normally closed as shown. The unit shall be as manufactured by Allen-Bradley or equivalent.

D. TIMERS (AS APPLICABLE):

1. TIMING RELAYS

- a. DPDT On Delay. The on-delay time delay relay shall have the following features: solid state timing circuitry; time delay setting via digital thumbwheel switches; digital elapsed-time display; timed-out indicator; 120 VAC 60 Hz operating voltage; two pole double throw (DPDT) delayed contacts; relay contact minimum full load rating 125 VAC 5 Amp; minimum electrical life at rated load 100,000 operations; din rail mounted 8-pin octal type socket mounting and hold-down springs. Manufacturer Idec series GT3D-3 with SR2P-06 socket and SFA-202 hold-down springs, or approved equal.
- b. 4PDT On Delay. The 4PDT on-delay time delay relay shall have the following features; solid state timing circuitry; time delay setting via hand or screw driver dial knob; power on and timed out LED indicators; four pole double throw (4PDT) delayed contacts; relay contact minimum full load inductive rating 125 VAC 0.8 Amp; minimum electrical life at rated load 200,000 operations; din rail mounted blade screw terminal socket and hold-down strings. Manufacturer Idec series GT5Y with SY4S-05 socket and SFA-2.02 hold-down springs, or approved equal.
- c. DPDT True Off Delay. The operation of the true off delay time delay relay shall be as follows: When voltage is applied to the coil, normally open contacts close and normally closed contacts open immediately; when voltage is removed from the coil, the timer begins timing; when preset time times out, contacts transfer to the OFF state; if power is reapplied before the preset time has timed out, the timing resets to the starting point of the timing period. The unit shall have the following features: solid state timing

circuitry; time delay setting via hand dial knob; 120 VAC 60 Hz operating voltage and power indicator; two pole double through (DPDT) delayed contacts; relay contact minimum full load rating 125 VAC 3 Amp (resistive); minimum electrical life at rated load 100,000 operations; din rail mounted 8-pin octal type socket mounting and hold-down springs. Manufacturer Idec series GT3F with SR2P-06 socket and SFA-202 hold-down springs; or approved equal.

2. MOTOR DRIVEN TIMERS: Motor driven timers shall be driven by a synchronous motor which starts timing when initiated by an external signal. Time settings shall be made by turning a knob on the front of the dial. A neon pilot light visible from the front of the timer shall glow red when the timer motor is energized. Visual indication shall be provided by a cycle progress pointer which advances to zero from the setting back to zero as time progresses. There shall be two sets of "instantaneous" NEMA form-C contacts which actuate when the timing is initiated. There shall be one set of "delayed" NEMA form-C contacts which actuates when the unit has timed out. When the timing cycle is completed, the timer shall automatically reset unless otherwise specified. The timer shall be mounted in a one-piece molded case that will be permanently mounted and wired. The timer shall be Eagle Cycle-flex reset timer, HP5 series; Automatic Timing Controls, Series 305D; or equal.

2.10 MAGNETIC CONTACTORS

A. MOTOR CONTACTORS:

Motor contactors shall be designed for continuous operation of induction motors at 600 V or less at 60 Hz and shall comply with NEMA ICS 2-210. Unless otherwise specified, minimum contactor size shall be NEMA size 1. The contactor shall be supplied with a normally open auxiliary contact for use as a hold-in contact as a minimum. Additional contacts shall be provided as specified. The coil voltage, frequency and number of poles shall be as specified.

2.11 INDIVIDUAL MOTOR STARTERS

- A. Full voltage non-reversing contactors used for across the line starters and designed for operation at 600 V AC, 60 hertz. Contactors and starters shall be NEMA standard rated and not equivalent. IEC equipment will not be considered. Starters shall be compatible with solid-state overload relays.

2.12 SAFETY DISCONNECT SWITCHES

A. NONFUSIBLE:

Where shown on the drawings as nonfusible, safety disconnect switches shall be heavy-duty, nonfusible, safety type rated 600 V AC. Unless otherwise specified, indoor enclosures shall be NEMA 12; enclosures installed in outdoor, wet, or corrosive areas shall be NEMA 4X, nonmetallic; and enclosures installed in hazardous areas shall be NEMA 7. Switch enclosures located in classified areas

shall be suitable for the specified classification. The operating handle shall be capable of being padlocked in the "off" position. The operator shall be a positive, quick-make, quick-break mechanism. Switch mechanisms shall be provided with one auxiliary contact that opens before the switchblades. This auxiliary contact shall be rated B150, per NEMA ICS 2-125.

B. FUSIBLE:

Where shown on the drawings as fusible, safety disconnect switches shall be heavy-duty, fusible, safety type rated 600 V AC. Fuse clips shall be UL Class R rejection type with Type RK-5 dual element fuses for a minimum 200,000-amp short circuit rating. Unless otherwise specified, indoor enclosures shall be NEMA 12; enclosures installed in outdoor, wet, or corrosive areas shall be NEMA 4X, stainless steel; and enclosures installed in hazardous areas shall be NEMA 7. Switch enclosures located in classified areas shall be suitable for the specified classification. The operating handle shall be capable of being padlocked in the "off" position. The operator shall be a positive, quick-make, quick-break mechanism. Switch mechanisms shall be provided with one auxiliary contact that opens before the switchblades. This auxiliary contact shall be rated B150, per NEMA ICS 2-125.

Switches shall be horsepower rated for motors and shall comply with NEMA KS-1. Switches shall be provided with defeatable door interlocks that prevent the door from opening when the operating handle is in the "on" position. Switches shall have line terminal shields. Switches shall be Cutler Hammer Type DH; General Electric Mill Duty, Type TH; or equal. Fuses shall be provided per the equipment manufacturer's recommendations.

2.13 ELAPSED TIME INDICATORS (IF USED)

Elapsed time indicators shall be panel mounted, nonresettable, six digit, hour indicator, rated 120 V AC, 60 Hz.

2.14 SPEED ADJUSTMENT POTENTIOMETER (IF USED)

The speed adjustment potentiometer shall be a single-turn, heavy-duty potentiometer. The unit shall consist of a molded resistance track rated at 2 W, 500 V. The resistance value shall be as shown, or if not shown then the resistance value shall be suitable for the application and chosen by the CONTRACTOR. The unit shall be equipped with a positive positioning feature to prevent backlash and movement due to vibration. The unit shall be bushing mounted using a NEMA type 13 oiltight mounting and shall include a legend plate with graduated markings from 0 to 100 percent and the word "SPEED." The unit shall be Allen-Bradley 800T or equal.

2.15 NAMEPLATES

Nameplates for all control panels, relays, timers, motor contactors and disconnect switches shall be provided.

PART 3 -- EXECUTION

3.1 GENERAL

- A. Install equipment in accordance with manufacturer's recommendations.
- B. Use appropriate conduit and conductor entry fittings with enclosures to maintain the specified enclosure environmental capability after installation.
- C. Equipment locations, if shown on Drawings, are approximate. Final locations shall be determined in accordance with field conditions and subject to OWNER's approval.

3.2 OUTLET AND DEVICE BOXES

- A. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.

- B. Sizes:

- 1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
- 2. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
- 3. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.
- 4. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

- C. Locations:

- 1. Drawing locations are approximate.
- 2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by OWNER.
- 3. Light Switch: Install on lock side of doors.
- 4. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

- D. Mounting Height:

- 1. If shown on Drawings dimensions given are to centerline of box.
- 2. Where specified heights do not suit structural features or finish, mount as directed by OWNER.

3. Light Switch: 48 inches above floor.
 4. Thermostat: 54 inches above floor.
 5. Convenience Receptacles.
 - a. General Interior Areas: 15 inches above floor.
 - b. Outdoor, All Areas: 24 inches above finished grade, or as directed by OWNER.
 6. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.
- E. Install plumb and level.
- F. Flush Mounted:
1. Install with concealed conduit.
 2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
 3. Holes in surrounding surface shall be no larger than required to receive box.
- G. Support boxes independently of conduit by attachment to building structure or structural member.
- H. Install bar hangers in frame construction or fasten boxes directly as follows:
1. Concrete or Brick: Bolts and expansion shields.
 2. Hollow Masonry Units: Toggle bolts.
 3. Steelwork: Machine screws.
- I. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
- J. Provide plaster rings where necessary.
- K. Boxes embedded in concrete or masonry need not be additionally supported.
- L. Install galvanized mounting hardware in industrial areas.
- M. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.
- N. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

O. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

P. Box Type (Steel Raceway System):

1. Exterior Locations:

- a. Exposed Raceways: Cast metal.
- b. Concealed Raceways: Cast metal.
- c. Concrete Encased Raceways: Cast metal.

2. Interior Locations:

- a. Exposed Rigid Conduit or IMC: Cast metal.
- b. Exposed EMT: Sheet steel.
- c. Concealed Raceways: Sheet steel.
- d. Concrete Encased Raceways: Cast metal.
- e. Lighting Circuits, Ceiling: Sheet steel.

3. Cast-In-Place Concrete Slabs: Sheet steel.

Q. Box Type, Corrosive Locations (PVC-Coated Rigid Galvanized Steel Raceway System): PVC-coated cast metal.

3.3 JUNCTION AND PULL BOXES

- A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
- B. Install pull boxes where necessary in raceway system to facilitate conductor installation.
- C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.
- D. Use conduit bodies as junction and pull boxes where no splices are required and their use is allowed by applicable codes.
- E. Installed boxes shall be accessible.
- F. Do not install on finished surfaces.
- G. Install plumb and level.

- H. Support boxes independently of conduit by attachment to building structure or structural member.
- I. Install bar hangers in frame construction or fasten boxes directly as follows:
 - 1. Wood: Wood screws.
 - 2. Concrete or Brick: Bolts and expansion shields.
 - 3. Hollow Masonry Units: Toggle bolts.
 - 4. Steelwork: Machine screws.
- J. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
- K. At or below grade:
 - 1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways
 - 2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location
 - 3. Obtain OWNER's written acceptance prior to installation in paved areas, roadways, or walkways
 - 4. Use boxes and covers suitable to support anticipated weights
- L. Flush Mounted:
 - 1. Install with concealed conduit
 - 2. Holes in surrounding surface shall be no larger than required to receive box
 - 3. Make edges of boxes flush with final surface
- M. Mounting Hardware:
 - 1. Noncorrosive Dry Areas: Galvanized.
 - 2. Noncorrosive Wet Areas: Stainless steel.
 - 3. Corrosive Areas: Stainless steel.
- N. Location/Type:
 - 1. Finished, Indoor, Dry: NEMA 250, Type 1.
 - 2. Unfinished, Indoor, Dry: NEMA 250, Type 12.

3. Unfinished, Indoor and Outdoor, Wet: NEMA 250, Type 4.
4. Steel Raceway System: Cast metal.
5. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
6. Nonmetallic Raceway System: Nonmetallic.
7. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.
8. Underground Conduit: Concrete.
9. Outdoor Locations Where Indicated Weatherproof (WP): NEMA 250, Type 3R.
10. Areas Not Otherwise Classified: NEMA 250, Type 12.

3.4 WIRING DEVICES

A. Switches:

1. Mounting Height: See Article OUTLET AND DEVICE BOXES.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switches such that toggle is in up position when switch is on.

B. Receptacles:

1. Install with grounding slot down and house in NEMA 3R rated enclosure.
2. Weatherproof Receptacles:
 - a. Install in cast metal box.
 - b. Install such that hinge for protective cover is above receptacle opening.

C. Switch, Motor Rated:

1. Install with switch operation in vertical position such that toggle is in up position when ON.
2. Install within sight of motor when used as a disconnect switch.
3. Mounting Height: See Article OUTLET AND DEVICE BOXES.
4. Enclosure Type: See Article OUTLET AND DEVICE BOXES.

3.5 DEVICE PLATES

- #### A. Securely fasten to wiring device; ensure a tight fit to box.

- B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.
- C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.
- D. Install with alignment tolerance to box of 1/16-inch.
- E. Types (Unless Otherwise Shown):
 - 1. Office: Plastic
 - 2. Exterior: Weatherproof
 - 3. Interior:
 - a. Flush Mounted Boxes: Plastic.
 - b. Surface Mounted, Metal Boxes:
 - 1) General Purpose Areas: Sheet Steel.
 - 2) Other Areas: Cast.
 - c. Surface Mounted, Aluminum Boxes:
 - 1) General Purpose Areas: Stamped.
 - 2) Other Areas: Cast.
 - d. Surface Mounted, Sheet Steel Boxes: Raised sheet steel.
 - e. Surface Mounted, Nonmetallic Boxes: Manufacturer's standard.

PART 4 -- MEASUREMENT AND PAYMENT

1.2 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 26 05 00 Electrical Work, General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

1.3 PAYMENT

Payment shall be made in accordance with Section 26 05 00 Electrical Work, General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 10 - ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 SUMMARY

- A. The work includes all labor, materials, and equipment required to furnish, install, and test AC induction motors as shown on the Drawings and as specified herein.

1.2 QUALITY ASSURANCE

- A. All motors shall be designed and constructed in accordance with the latest edition of NEMA Standard MG1 and applicable portions of the NEC. Motors for use in hazardous locations, as defined in NEC Article 500 shall be approved by a recognized testing laboratory. For this specification section, the term "recognized" shall mean having been listed as acceptable for at least 1 year by the authority having jurisdiction, as defined in the NEC.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Submittal of motor data shall be in conjunction with the piece of mechanical equipment served. See individual sections for submittals required
- C. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:
 - 1. Machine name and specification number of driven machine
 - 2. Motor manufacturer
 - 3. Motor type or model and dimension drawing. Include motor weight.
 - 4. Nominal horsepower
 - 5. NEMA design
 - 6. Enclosure
 - 7. Frame size
 - 8. Winding insulation class and temperature rise class
 - 9. Voltage, phase, and frequency ratings
 - 10. Service factor
 - 11. Full load current at rated horsepower for application voltage

12. Full load speed
13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.
14. Type of thermal protection or over temperature protection, if included
15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable
16. Bearing data. Include recommendation for lubricants of re-lubricatable type bearings.
17. If utilized with a variable frequency drive, verify motor is inverter duty rated. Include minimum speed at which motor may be operated for the driven machinery.
18. Power factor at 1/2, 3/4 and full load.
19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

1.4 WARRANTY

- A. The motors shall be warranted for both labor, equipment, and all components for a 2-year period after final acceptance and commissioned.

1.5 PRODUCT DELIVERY AND STORAGE

- A. All motors shall be shipped to the jobsite with all openings plugged, taped, or otherwise sealed to prevent entry of foreign materials, rodents, etc.
- B. Motors stored at the jobsite shall be in a dry location protected from sun and rain, unless otherwise authorized by the OWNER.

PART 2 -- PRODUCTS

2.1 SERVICE CONDITIONS

- A. All equipment shall be designed and built for industrial service and be capable of delivering rated horsepower under the following applicable conditions:
 1. 40°C maximum ambient temperature.
 2. System voltage variations to +10% of nameplate rating.
 3. System frequency variations to +5% of nameplate rating.
 4. Combined voltage and frequency variations to +10% total, as long as frequency does not exceed +5%.

2.2 VOLTAGE

- A. Motors rated one-third horsepower and smaller shall be designed and connected for operation at 120 volts single phase. Motors one-half horsepower and larger shall be rated for 120-volt or 240-volt single phase. In all cases where motor service connection voltage is depicted, CONTRACTOR shall provide the motor to operate on the voltage shown.

2.3 ENCLOSURE TYPES

- A. Enclosures, unless indicated on the plans or elsewhere, shall be identified as follows:
 - 1. TEFC: totally enclosed, fan cooled.
- B. TEFC motors shall have a corrosion-resistant finish, or as otherwise noted, or called out in other sections.
- C. Drip-proof motors shall be designed such that particles of solid or liquid material falling at any angle from 0 to 15 degrees downward from the vertical shall not enter the ventilating openings or interfere with successful operation, as defined by NEMA standards.
- D. TEFC motors shall conform to the appropriate NEMA standards and shall be provided with drilled and tapped holes to drain all cavities within the motor. Motors with frames 286T or smaller shall have corrosion-resistant plugs in the drain holes. Motors with frame 324T or larger shall be provided with automatic breather-drain devices.

2.4 ELECTRICAL REQUIREMENTS FOR MOTORS

- A. Service factor for single-phase motors shall be 1.15 or greater unless indicated otherwise on the Drawings or component specifications.
- B. Service factor for all 3 phase motors shall be 1.15 unless indicated otherwise on Drawings or in component specifications.
- C. Time rating: All motors covered by this section shall have continuous time ratings.
- D. Currents: Locked rotor currents shall not exceed the maximum values for NEMA Design B.
- E. Protection: Current density and heating characteristics shall be such that the motors shall not burn out if subjected to a maximum of a 20-second stall at 6 times full-load current.
- F. Rating: Motors shall not be required to operate at greater than their nameplate horsepower. Use of the service factor shall not be allowed under conditions of rated voltage and frequency.
- G. Insulation: All motors shall have insulation systems conforming to the requirements for NEMA Class B or higher. Motors powered from VFD's shall be insulated to meet the requirements of VFD-generated over-voltages in accordance with NEMA MG1, Part 31.
- H. All motors shall be rated for variable frequency drive (VFD) operation, and for 10 HP or larger, shall have winding embedded resistance temperature detectors (RTD), minimum

two in each phase. The RTD's shall be of the platinum type, 100 ohm at 0 degrees C. They shall be wired to a connection box with a terminal strip for external connections.

- I. Motor efficiency shall be in accordance with the regulating State Energy Code.

2.5 NAMEPLATES

- A. Motor nameplates shall be of a noncorrosive metal that is not discolored by hydrogen sulfide. Nameplates shall be engraved or stamped and shall be fastened to the motor frame with screws or drive pins of the same material.
- B. Nameplates shall indicate clearly all the items of information enumerated in NEMA Standard MG1-0.37, MG1-10.38, or MG1-20.60, as applicable.
- C. The CONTRACTOR shall coordinate the motor nameplate location so it is readily visible for inspection in the completed machine, and it shall not be painted.

2.6 MECHANICAL REQUIREMENTS FOR MOTORS

- A. Frame sizes. Frames shall conform to latest NEMA Standard MG1-11.31 for "T" frames, and all dimensions shall meet NEMA Standards insofar as they apply.
- B. Shafts shall be in accordance with NEMA "T" or "TS" dimensions. Long shafts shall be suitable for belt, chain, or gear drive, within limits established by good industrial practice and documented by NEMA Standards MG1-14.42 and MG1-14.07. Short shafts shall be used for direct connection.
- C. Connection diagrams shall be permanently attached to the motor, either inside the conduit box or on the motor frame, in a location readable from the conduit box side.
- D. External finish: Shall be corrosion resistant for outdoor operation.
- E. Hardware: All bolts, screws, and other external hardware shall be treated for resistance to corrosion by painting with a rust inhibitive primer immediately after installation and two final coats when final equipment painting is performed.

PART 3 -- EXECUTION

3.1 TESTS

- A. Insulation check. The OWNER may test the insulation resistance of the motor at any time after delivery of the motor to the jobsite or at any time during the warranty period. Tests for acceptability shall be made using a 1,000-volt megohm meter (megger). Interpretations of test results for minimum acceptable values of insulation resistance shall be made in accordance with IEEE No. 43. All deficiencies identified by any testing shall be corrected by the CONTRACTOR.
- B. Load testing. The OWNER may test a motor at any time after delivery of the motor to the jobsite or at any time during the warranty period to determine its ability to operate at nameplate current or less, under all normal operating conditions. In the event that a motor

does not meet the load test requirements, the CONTRACTOR shall replace the motor at no additional cost to OWNER.

- C. Perform additional tests listed in ANSI/NETA ATS-2017 Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.

3.2 PREPARATION FOR SHIPMENT

- A. Protective coating. Before shipment, the shaft extension and any other external bare exposed metal parts of each motor shall be coated with an easily removable rust preventive.
- B. Packaging. All motors shall be packed in Styrofoam or securely fastened to a hardwood skid or pallet for fork-truck handling and shall be covered for protection against dirt and moisture during transit and for short-time outdoor storage.

PART 4 -- PART 4 -- MEASUREMENT AND PAYMENT

1.1 MEASUREMENT

4.1 Work performed under this section shall be measured as incidental to Section 26 05 00 Electrical Work, General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

1.2 PAYMENT

4.2 Payment shall be made in accordance with Section 26 05 00 Electrical Work, General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 19 - INSULATED WIRE AND CABLE

PART 1 -- GENERAL

1.1 REFERENCES

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

1. American Society for Testing and Materials (ASTM):
 - a. A167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - b. B3, Standard Specification for Soft or Annealed Copper Wire
 - c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - d. B263, Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations
3. Insulated Cable Engineer's Association, Inc. (ICEA) and National Electrical Manufacturers' Association (NEMA):
 - a. ICEA S-58-679, Standard for Control Cable Conductor Identification
 - b. ICEA S-73-532 / NEMA WC57, Standard for Control, Thermocouple Extension, and Instrumentation Cables
 - c. ICEA S-105-692, 600 Volt Single Layer Thermoset Insulated Utility Underground Distribution Cable
 - d. ICEA S-81-570, Direct Burial, 600 Volt, Ruggedized Insulation
 - e. ICEA T-29-520, Procedure for Conducting Vertical Cable Tray Flame Test With a Theoretical Heat Input of 210,000 Btu/hour
 - f. NEMA CC1, Electric Power Connectors for Substations
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)
5. Underwriters Laboratories, Inc. (UL):
 - a. 13, Standard for Safety Power-Limited Circuit Cables
 - b. 44, Standard for Safety Thermoset-Insulated Wires and Cables

- c. 486A, Standard for Safety; Wire Connectors and Soldering Lugs for Use with Copper Conductors
- d. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
- e. 910, Standard for Safety Test Method for Flame Propagation and Smoke Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
- f. 1072, Standard for Safety Medium-Voltage Power Cables
- g. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
- h. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings:
 - 1. Wire and cable descriptive product information.
 - 2. Wire and cable accessories descriptive product information.

1.3 UL COMPLIANCE

- A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 600-VOLT RATED CONTROL AND POWER CABLE

- A. General:
 - 1. Type Tray Cable (TC), meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu/hr, and NFPA 70, Article 340, or UL 13 Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725
 - 2. Conform to applicable requirements of NEMA WC 3, WC 5, and WC 7
 - 3. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark
 - 4. Suitable for installation in open air, in cable trays, or conduit

5. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations

B. Multiconductor Control Cable:

1. Conductors:
 - a. Material: Copper
 - b. Size: No. 14 AWG
 - c. Stranding: Class B
2. Insulation:
 - a. Type: Cross-linked polyethylene (XLP), 600 V rated
 - b. Standards: UL 44 listed as Type XHHW-2 rated VW-1
 - c. Conductor group bound with spiral wrap of barrier tape
 - d. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2
3. Jacket: Chlorinated polyethylene (cross-linked type) (CPE) per ICEA S-73-532 and UL 1277.
4. Cable: Passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test
5. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

C. Multiconductor Power Cable:

1. Conductors:
 - a. Material: Copper
 - b. Stranding: Class B
2. Insulation:
 - a. Type: Flame retardant, cross-linked polyethylene (FR-XLP), 600 volt rated
 - b. Standards: UL 44 listed as Type XHHW-2, rated VW-1
 - c. Color Code: Conductors, size No. 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 2. Conductors size No. 6 AWG and larger, ICEA S-73-532, Method 4. Alternatively, conductor sizes No. 6 AWG and larger, color tape wrapped around the ends of each the conductor shall meet this color coding requirement.
 - d. Jacket: Chlorinated polyethylene (cross-linked type) (CPE) per ICEA S-73-532 and UL 1277
3. Cable passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60
8	10	3	0.66	60
		4	0.72	
6	8	3	0.74	60
		4	0.81	
4	6	3	0.88	60
		4	0.97	
2	6	3	1.01	80
		4	1.11	
1/0	6	3	1.22	80
		4	1.35	

Conductor Size	Minimum Ground Wire Size	No. of Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
2/0	4	3	1.32	80
		4	1.46	
4/0	4	3	1.56	80
		4	1.78	

D. Cable for Variable Frequency Drive Application (VFD)

1. The variable frequency drive supplier shall confirm appropriate rating and configuration of the cable and adjust the below specified requirements accordingly.
2. Conductors: Copper, 3-conductor configuration with symmetric bare ground conductors.
3. Insulation: XLPE or EPR for conductors and PVC for jacket.
4. Voltage Rating: 1000V
5. Cable passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test

E. Single Conductor Power Cable

1. Conductors:
 - a. Material: Copper
 - b. Stranding:
 - 1) Class B
 - 2) Indoor lighting and receptacle circuits No. 10 AWG and smaller: Solid copper conductor if not terminated on terminal blocks.
 - c. Insulation:
 - 1) Conductors No. 6 AWG and larger: Flame retardant, cross-linked polyethylene (FR-XLP)
 - 2) Conductors smaller than No. 6 AWG: Polyvinyl chloride (PVC) sheathed with nylon
 - d. Standards: No. 6 AWG and larger: UL 44 listed as Type XHHW-2, rated VW-1
 - e. Jacket:

- 1) Conductors No. 6 AWG and larger: Chlorinated polyethylene (cross-linked type) (CPE) per ICEA S-73-532 and UL 1277.
 - 2) Conductors smaller than No. 6 AWG: Nylon
2. Cable passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test
- F. Direct Burial and Aerial Conductors and Cables:
1. Type USE/RHH/RHW insulation, UL 854 listed or Type RHW-2/USE-2
 2. Conform to physical and minimum thickness requirements of NEMA WC 3
- G. Flexible Cords and Cables:
1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62
 2. Conform to physical and minimum thickness requirements of NEMA WC 8
- 2.2 300 and 600-VOLT RATED INSTRUMENTATION CABLE
- A. General:
1. Type PLTC, meeting requirements of UL 13, UL Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725
 2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark
 3. Suitable for installation in open air, in cable trays, or conduit
 4. Minimum Temperature Rating: 105 degrees C
 5. Passes vertical tray flame test
 6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant
 7. 300V insulated instrumentation cable may be used in applications non-fire protection related and when routed in race way with circuits less than 300V. For all other applications 600V insulated cable shall be used.
 8. All control and signal wiring shall use jacketed cable.
- B. Twisted, Shielded Pair Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55.
1. Size: No. 18 AWG, unless otherwise stated in the cable schedule or drawings
 2. Outer Jacket: 60-mil nominal
 3. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage

4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
 - b. Tinned copper drain wire
 - c. Insulation: PVC
 - d. Color Code: Pair conductors black and white

- C. Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting requirements of NEMA WC 55.
 1. Size: No. 18 AWG, unless otherwise stated in the cable schedule or on the drawings
 2. Outer Jacket: 60-mil nominal thickness
 3. Individual Pair Shield: double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage
 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
 - b. Tinned copper drain wire
 - c. Insulation: PVC
 - d. Color Code: Triad conductors black, red, and white

- D. Multi-Twisted, Shielded Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.
 1. Conductors:
 - a. Size: No. 18 AWG, unless otherwise stated in the cable schedule or on the drawings
 - b. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
 - c. Tinned copper drain wires
 - d. Insulation: PVC
 - e. Color Code: Pair conductors black and white, with white conductor numerically printed for group identification
 - f. Individual Pair Shield: aluminum/mylar

- g. Cable Shield: double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage

2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.52	50
8	0.71	60
12	0.85	60
16	1.05	80
24	1.20	80
36	1.37	80
50	1.71	80

- E. Multi-Twisted Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.

1. Conductors:

- a. Size: No. 18 AWG, unless otherwise stated in the cable schedule or on the drawings
- b. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
- c. Tinned copper
- d. Group drain wire
- e. Insulation: PVC
- f. Color Code: Pair conductors black and white, with white conductor numerically printed for group identification
- g. Cable Shield: double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage

2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.49	50
8	0.65	60
12	0.76	60
16	0.89	80
24	1.03	80
36	1.18	80
50	1.45	80

F. Fire Alarm Cable: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760, Fire Alarm Systems:

1. Cable: Pass UL 70,000 Btu flame test and listed by California State Fire Marshall
2. Outer jacket: Red in color, identified along its entire length as fire protective signaling circuit cable
3. Conductors:
 - a. Solid, tinned, or bare copper
 - b. Insulation: 15 mil PVC

2.3 MEDIUM VOLTAGE POWER CABLE

- A. Type: Three-conductor, armored, 15-kV, MV-105
- B. Conductors: Bare annealed copper per ASTM B3
- C. Grounding Conductor: Uncoated copper
- D. Size: As shown on Drawings
- E. Insulation: 133% EPR (220 mils) for conductors and PVC in accordance with ICEA for jacket
- F. Insulation Shield: 5 mil copper tape with 25% overlap
- G. Armor: Impervious, continuous welded corrugated aluminum
- H. Vertical Cable Tray Flame Test: 210,000 BTU/hr per ICEA T-29-520

- I. Service Conditions: The cable shall be suitable for aerial, direct burial and conduit installations in wet and dry locations.
- J. Terminations: Cold shrink, outdoor type as manufactured by 3M, or equal.

2.4 GROUNDING CONDUCTORS

- A. Equipment: Stranded copper with green, type USE/RHH/RHW-XLPE or THHN/THWN, insulation.
- B. Direct Buried or Exposed: Bare stranded copper, No. 4/0 AWG.

2.5 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

- 1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510
- 2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88

B. Identification Devices:

- 1. Sleeve: Permanent, PVC, yellow or white, with legible machine-printed black markings
- 2. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive
 - b. Self-laminating protective shield over text
 - c. Machine printed black text
- 3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate
- 4. Tie-On Cable Marker Tags:
 - a. Chemical resistant white tag
- 5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum

C. Connectors and Terminations:

- 1. Nylon, Self-Insulated Crimp Connectors
- 2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator
- 3. Self-Insulated, Set Screw Wire Connector:

- a. Two-piece compression type with set screw in brass barrel
 - b. Insulated by insulator cap screwed over brass barrel
- D. Cable Lugs:
- 1. In accordance with NEMA CC 1
 - 2. Rated 600 volts of same material as conductor metal
 - 3. Insulated, Locking-Fork, Compression Lugs:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity
 - b. Seamless
 - 4. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity

2.6 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

PART 3 -- EXECUTION

3.1 GENERAL

- A. Installation shall conform to NEC and NESC requirements.
- B. Conductor storage, handling, and installation to be in accordance with manufacturer's recommendations.
- C. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.
- D. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- E. Terminate all conductors and cables, unless otherwise indicated.
- F. Tighten screws and terminal bolts in accordance with UL 486A for copper conductors.
- G. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

- H. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.
- I. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- J. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.
- K. Cable Tray Installation:
 - 1. Install wire and cable parallel and straight in tray
 - 2. Bundle, in groups, all wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet
 - 3. Clamp cable bundles prior to making end termination connections
 - 4. Separate cables of different voltage rating in same cable tray with metallic barriers
 - 5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
 - Horizontal Runs: 20 feet
 - Vertical Runs: 5 feet
- L. Medium voltage cable: Secure to walls and ceilings using clamps recommended by cable manufacturer. Maximum support spacing: 6-ft.

3.2 POWER CONDUCTOR COLOR CODING

- A. Conductors 600 Volts and Below:
 - 1. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide
 - 2. No. 8 AWG and Smaller: Provide colored conductors
 - 3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with an identifiable colored strip, other than green, in accordance with NFPA 70.

3.3 CIRCUIT IDENTIFICATION

- A. Circuits Appearing in Circuit Schedules: Identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Not Appearing in Circuit Schedules:
 1. Assign circuit name based on device or equipment at load end of circuit.
 2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
- C. Method:
 1. Conductors No. 3 AWG and Smaller: Identify with sleeves or heat bond markers

2. Cables, and Conductors No. 2 AWG and Larger:
 - a. Identify with marker plates; or
 - b. Tie-on cable marker tags
 - c. Attach with nylon tie cord
3. Taped-on markers or tags relying on adhesives not permitted

3.4 CONDUCTORS 600 VOLTS AND BELOW

- A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.
- B. Do not splice incoming service conductors and branch power distribution conductors No. 6 AWG and larger, unless specifically indicated or approved by OWNER.
- C. Connections and Terminations:
 1. Install wire nuts only on solid conductors
 2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors
 3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors No. 12 AWG and smaller
 4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 4 AWG through No. 2/0 AWG.
 5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors No. 3/0 AWG and larger
 6. Install uninsulated terminators bolted together on motor circuit conductors No. 10 AWG and larger
 7. Tape insulate all uninsulated connections
 8. Place no more than one conductor in any single-barrel pressure connection
 9. Install crimp connectors with tools approved by connector manufacturer
 10. Install terminals and connectors acceptable for type of material used
 11. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose
 - b. Tool shall provide complete, controlled crimp and shall not release until crimp is complete

- c. Do not use plier type crimpers
- D. Do not use soldered mechanical joints.
- E. Splices and Terminations:
 - 1. Indoors: Use general purpose, flame retardant tape
 - 2. Outdoors: Use flame retardant, cold- and weather-resistant tape
 - 3. Cap spare conductors and conductors with UL listed end caps
- F. Cabinets, Panels, and Motor Control Centers:
 - 1. Remove surplus wire, bridle and secure
 - 2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors
- G. Control and Instrumentation Wiring:
 - 1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs
 - 2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions
 - 3. Locate splices in readily accessible cabinets or junction boxes using terminal strips
 - 4. Cable Protection:
 - a. Under Infinite Access Floors: May be installed without bundling
 - All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least 1/2 inch in diameter
 - Maintain integrity of shielding of instrumentation cables
 - Ensure grounds do not occur because of damage to jacket over the shield
- H. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 26 05 00 Electrical Work, General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 26 05 00 Electrical Work, General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 26 – GROUNDING

PART 1 -- GENERAL

1.1 REQUIREMENTS

- A. Provide a power grounding system for the hatchery facility as required by the National Electrical Code (NFPA) and as shown on the engineering plans.
- B. CONTRACTOR shall ensure that all grounding points are restored after any modifications and installation of new equipment.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this Section:
 - 1. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings:
 - 1. Product Data:
 - a. Exothermic weld connectors.
 - b. Mechanical connectors.
 - c. Compression connectors.
 - d. Grounding cables.
 - 2. Shop Drawings
 - a. Grounding system layout showing ground cable routing and interconnections to existing grounding system.

1.4 UL COMPLIANCE

- A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 GROUND CONDUCTORS

- A. As specified in Section 26 05 19 – Insulated Wire and Cable.

2.2 CONNECTORS

- A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers:
 - a. Erico Products, Inc.
 - b. Thermoweld
 - c. Other manufacturers as approved

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
 - a. Burndy Corp.
 - b. Thomas and Betts Co.
 - c. Ilso Corp.
 - d. Other manufacturers as approved

C. Mechanical Type: Split-bolt, saddle, cone screw type or embedded plate type; copper alloy material.

2. Manufacturers:
 - a. Burndy Corp.
 - b. Thomas and Betts Co.
 - c. Other manufacturers as approved

2.3 GROUND RODS

A. Copper Bonded Ground Rod:

1. Length: 10 feet
2. Diameter: 5/8"
3. Manufacturers:
 - a. nVent ERICO

PART 3 -- EXECUTION

3.1 GENERAL

- A. Grounding shall be in compliance with NFPA 70.
- B. Install service entrance grounding as shown on the drawings.
- C. Ground each system neutral to nearest effectively grounded building structural steel member or separate grounding electrodes.

- D. Ground each section of metal railing, metal grating, stairs, building frames, motor frames, junction boxes, raceways, and equipment enclosures and tie to existing ground connection points as shown on engineering plans. Remove paint and corrosion to ensure high conductivity connection when making connections to existing grounding systems.
- E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.
- F. Shielded Instrumentation Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.
- G. Shielded Control Cables:
 - 1. Ground analog signal cable shields at the source.
 - 2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
 - 3. Do not ground instrumentation cable shield at more than one point. Instrumentation cables shall be grounded at the voltage source, with the opposite end insulated from ground.

3.2 WIRE CONNECTIONS

- A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.
- B. Connect ground conductors to raceway grounding bushings.
- C. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.
- D. Connect enclosure of equipment containing ground bus to that bus.
- E. Bolt connections to equipment ground bus.
- F. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.
- G. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.3 MOTOR GROUNDING

- A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.
- B. Motors Less Than 10 hp: Furnish compression, spade-type terminal connected to conduit box mounting screw.
- C. Motors 10 hp and Above: Tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

- D. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.4 CONNECTIONS

A. General:

1. Above grade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Below grade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. CONTRACTOR shall notify OWNER prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 26 05 00 Electrical Work, General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 26 05 00 Electrical Work, General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 05 43 - RACEWAYS

PART 1 -- GENERAL

1.1 REFERENCES

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

1. American National Standards Institute (ANSI):

C80.1	Rigid Steel Conduit-Zinc Coated
C80.3	Electrical Metallic Tubing-Zinc Coated
C80.5	Aluminum Rigid Conduit
C80.6	Intermediate Metal Conduit (IMC)-Zinc Coated

2. National Electrical Contractor's Association, Inc. (NECA): 5055, Standard of Installation

3. National Electrical Manufacturers Association (NEMA):

RN 1	Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
TC 2	Electrical Polyvinyl Chloride Plastic Tubing (PVC) and Conduit
TC 3	PVC Fittings for Use with Rigid PVC Conduit and Tubing
TC 6	PVC and ABS Plastic Utilities Duct for Underground Installation
VE 1	Metallic Cable Tray Systems

4. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)

5. Underwriters Laboratories, Inc. (UL):

1	Standard for Safety Flexible Metal Conduit
6	Standard for Safety Rigid Metal Conduit
360	Standard for Safety Liquid-Tight Flexible Steel Conduit
514B	Standard for Safety Fittings for Cable and Conduit
514C	Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
651	Standard for Safety Schedule 40 and 80 Rigid PVC Conduit

651A	Standard for Safety Type EB and A Rigid PVC Conduit and HDPE Conduit
797	Standard for Safety Electrical Metallic Tubing
870	Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
1660	Standard for Safety Liquid-Tight Flexible Nonmetallic Conduit

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings:
 - 1. Manufacturer's Literature:
 - a. Conduits of all types to be used
 - b. Other wireways
 - 2. Cable Tray System:
 - a. Dimensional drawings, calculations, and descriptive information
 - b. NEMA load/span designation and how it was selected
 - c. Layout drawings and list of accessories being provided
 - 3. Conduit and cable tray Layouts:
 - a. Plans and sections showing arrangement and location of conduit and duct bank to be used
 - b. Drawings shall be prepared using AutoCAD® files in 2014 or later version

1.3 UL COMPLIANCE

- A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 CONDUIT AND TUBING

- A. Rigid Galvanized Steel Conduit (RGS):
 - 1. Meet requirements of ANSI C80.1 and UL 6
 - 2. Material: Hot-dip galvanized, with chromated protective layer

- B. Intermediate Metal Conduit (IMC):
 - 1. Meet requirements of ANSI C80.6 and UL 1242
 - 2. Material: Hot-dip galvanized, with chromated and lacquered protective layer
- C. Electric Metallic Tubing (EMT):
 - 1. Meet requirements of ANSI C80.3 and UL 797
 - 2. Material: Hot-dip galvanized, with chromated and lacquered protective layer
- D. PVC Schedule 40 and 80 Conduit:
 - 1. Meet requirements of NEMA TC 2 and UL 651
 - 2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors
- E. Flexible Metal, Liquid-Tight Conduit:
 - 1. UL 360 listed for 105 degrees C insulated conductors
 - 2. Material: Galvanized steel, with an extruded PVC jacket
- F. Flexible Metal, Non-Liquid-Tight Conduit:
 - 1. Meet requirements of UL 1
 - 2. Material: Galvanized steel
- G. Flexible, Nonmetallic, Liquid-Tight Conduit:
 - 1. Material: PVC core with fused flexible PVC jacket
 - 2. UL 1660 listed for:
 - a. Dry Conditions: 80 degrees C insulated conductors
 - b. Wet Conditions: 60 degrees C insulated conductors

2.2 FITTINGS

- A. Rigid Galvanized Steel and Intermediate Metal Conduit:
 - 1. General:
 - a. Meet requirements of UL 514B
 - b. Type: Threaded, galvanized -- Set screw and threadless compression fittings not permitted

2. Bushing:
 - a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C
 3. Grounding Bushing:
 - a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs
 4. Conduit Hub:
 - a. Material: Malleable iron with insulated throat with bonding screw
 - b. UL listed for use in wet locations
 5. Conduit Bodies:
 - a. Sized as required by NFPA 70
 6. Couplings: As supplied by conduit manufacturer
 7. Unions:
 - a. Concrete tight, hot-dip galvanized, malleable iron
 8. Cable Sealing Fittings:
 - a. To form watertight nonslip cord or cable connection to conduit
 - b. For Conductors with OD of 1/2-in or less: Neoprene bushing at connector entry
- B. Electric Metallic Tubing:
1. Meet requirements of UL 514B
 2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted
 3. Electro zinc-plated inside and out
 4. Raintight
- C. PVC Conduit and Tubing:
1. Meet requirements of NEMA TC-3
 2. Type: PVC, slip-on
- D. Flexible Metal, Liquid-Tight Conduit:
1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C

2. Insulated throat and sealing O-rings
- E. Flexible Metal, Non-Liquid-Tight Conduit:
1. Meet requirements of UL 514B
 2. Body: Galvanized: steel
 3. Throat: Nylon insulated
 4. 1-1/4-inch (in) Conduit and Smaller: One screw body
 5. 1-1/2-in Conduit and Larger: Two screw body
- F. Flexible, Nonmetallic, Liquid-Tight Conduit:
1. Meet requirements of UL 514B
 2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut
 3. Body/compression nut (gland) design to assure high mechanical pullout strength and watertight seal
- G. Flexible Coupling, Hazardous Locations:
1. Approved for use in the atmosphere involved
 2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
 3. Outer bronze braid and an insulating liner
 4. Conductivity equal to a similar length of rigid metal conduit
- H. Watertight Entrance Seal Device:
1. New Construction:
 - a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp
 2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp
- 2.3 CABLE TRAYS
- A. Meet requirements of NEMA VE 1.
 - B. Type: Ladder, of welded construction.

- C. Material: Copper-free aluminum alloy 6063-T6finish.
- D. Dimensions: 6-in NEMA nominal inside fill depth and fittings. Width shall be minimum 18-in, 9-in rung spacing, and bending radius to suit application. Cable tray shall be double or single layer as indicated on the engineering plans.
- E. Fittings of same cross-sectional tray area, and hardware of same material as cable tray.
- F. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.
- G. Provide next higher NEMA VE 1 class designation than required for support of designed span length.
- H. Design Loads: Use working load adequate for actual cable installed plus 20 percent additional weight allowance for future cables with safety factor of 1.5 in accordance with NEMA VE 1, Table 3-1.
- I. Expansion Joints: NEMA VE 1 for 50 degrees F maximum temperature variation.
- J. Furnish Cable Tray with no sharp edges, burrs, or weld projections.

2.4 WARNING TAPE

- A. Material: 6-in wide, 4-mil thick film of inert material such as polyethylene plastic; impervious to acids, alkalis, and other soil components; and supplied in continuous roll.

Color/Message: Bright yellow, red, or orange, electrically-detectable, film, with two-line message in permanent 1-in bold letters, one side only. The following message to be repeated continuously the full length of the tape:

"CAUTION CAUTION CAUTION"

"[HIGH-VOLTAGE] ELECTRIC LINE BELOW"

PART 3 -- EXECUTION

3.1 GENERAL

- A. Conduit and tubing sizes shall be based on the use of copper conductors.
- B. Crushed or deformed raceways not permitted.
- C. Maintain raceway entirely free of obstructions and moisture.
- D. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- E. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

- F. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- G. Group raceways installed in same area.
- H. Proximity to Heated Piping: Install raceways minimum 12-in from parallel runs.
- I. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
- J. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes. Installation shall be plumb, square, and true.
- K. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.
- L. Install watertight fittings in outdoor, underground, or wet locations.
- M. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- N. Metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- O. Do not install raceways in concrete equipment pads, foundations, or beams, unless they are required for bottom entry to control panels, motor control centers, switchgear, or similar equipment.
- P. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- Q. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- R. Install conduits for fiber optic cables, telephone cables, and Category 5 data cables in strict conformance with the requirements of EIA/TIA 596-A.
- S. Conduit larger than 1-in shall not be embedded in concrete slabs, walls, foundations, columns, or beams, unless approved by OWNER.
- T. Embedded conduits emerging flush with concrete slab or wall shall be provided with bell ends.
- U. Install pull boxes and junction boxes as required to meet NEC requirements or for ease of cable pulling, whether or not they are specifically shown on the Drawing.

3.2 CONDUIT APPLICATION

- A. Diameter: Minimum 3/4-in for lighting applications, 1-in for all other locations.
- B. Exterior, Exposed:

1. Rigid galvanized steel
 2. Motors and transformers: See "Connections"
- C. Interior, Exposed:
1. Rigid galvanized steel
 2. Motors and transformers: See "Connections"
- D. Interior, Concealed and Dry (Not Embedded in Concrete):
1. IMC or EMT
- E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors:
1. Rigid galvanized steel
 2. RGS shall be wrapped six inches above and below penetration with corrosion protective material.
- F. Direct Earth Burial:
1. PVC schedule 80 for all direct buried applications, unless otherwise noted on the drawings.
 2. Buried RGS shall be wrapped with corrosion protective material minimum six inches above entrance/exit ground surface material.

3.3 CONDUIT SIZE, ARRANGEMENT, AND SUPPORT

- A. Minimum conduit size:
1. The minimum conduit size shall be 1-in (27 mm) trade size in buildings or for exterior above ground installations.
 2. The minimum conduit size shall be 1.25-in (35 mm) trade size for underground and under building slab installations.
 3. 1-in (27 mm) EMT/FMC permitted under certain conditions addressed elsewhere in these Specifications or as detailed on the Drawings.
- B. Conduit systems shall be worked into complete, integrated arrangements, with like elements to present an orderly, neat, and workmanlike appearance as specified herein.
- C. Install conduit, raceways, junction boxes and device back boxes concealed, except as shown or noted otherwise. Conduits, raceways, junction boxes and device back boxes may be exposed in unfinished areas or in mechanical equipment rooms. Where conduits or raceways are exposed, above suspended ceilings, or under raised floors, they shall run parallel with walls or structural elements.

- D. Vertical runs shall be plumb; horizontal runs level and parallel with structure, as appropriate. Groups shall be racked together neatly with both straight runs and bends parallel and uniformly spaced.
- E. Install as high as practicable to maintain adequate headroom shown or required. Notify OWNER before installation whenever headroom of less than 7 feet (ft) 6-in (2.3 m) will result. Coordinate with work of other Divisions to achieve proper headroom as specified in this Section. In area above suspended ceilings, run conduits on wall surfaces wherever possible, instead of by hanging.
- F. Conduits shall be securely fastened in place at intervals of not more than those required by the Code for the respective conduit type and size, with suitable clamps or fasteners of approved type, and vertical conduits shall be properly supported to present a mechanically rigid and secure installation.
- G. Maintain at least 6-in (150 mm) clearance between conduit and piping. Maintain 12-in (300 mm) clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
- H. No conduit shall be fastened to other conduits or pipes or installed so as to prevent the ready removal of other pipes for repairs. No conduits shall be attached to suspended ceiling support wiring systems or seismic bracing wiring for lighting fixtures.
- I. For concrete (block or cast-in-place) structures, conduit directly supported from floor, walls, and ceiling shall be spaced out at least 1/4 in (6 mm) using one-hole malleable straps with pipe spacers or, if three (3) or more conduits are located in a parallel run, they shall be spaced out from the structure approximately 5/8 in (16 mm) to 1 in (27 mm) by means of framing channel.
- J. Individual conduits hung from roof structure shall be supported by split-ring hangers and wrought-iron hanger rods. Where three (3) or more conduits are suspended from the ceiling in parallel runs, use steel channels, Kindorf, Unistrut or equal, hung from 1/2-in rods to support the conduits. The conduit on these channels shall be held in place with conduit clamps designed for the particular channel that is used.
- K. Secure conduit racks to concrete walls and ceilings by means of cast-in-place anchors; die-cast, rustproof alloy expansion shields; or cast flush anchors. Wooden plugs, plastic inserts, or gunpowder driven inserts shall not be used as a base to secure conduit supports. Conduit shall be supported immediately on each side of a bend and not more than 3-ft (0.9 m) from an enclosure where a straight run of conduit ends.
- L. Welding, brazing, or other heating of the conduit is not permitted.
- M. Clearance: Do not obstruct spaces required by Code in front of electrical equipment, access doors, etc.
- N. Conduits, 2-in (50 mm) trade size or smaller O.D. but not larger than one-third concrete thickness, may be installed in structural concrete, between steel and bottom of slab, only where permitted by the Project Manager. Conduit may be in contact with reinforcing or other conduit where crossing at right angle, but maintaining minimum spacing of three times O.D. elsewhere.

- O. The interior of raceways shall be thoroughly clean and free from cement, paint, grease, plaster, and dirt.
- P. Empty conduit in which wire is to be installed by others, including telephone and computer conduits, shall have pull lines installed. The pull line shall be 3/32 in (2.3 mm) nylon or polyolefin having not less than 200 pound (90.7 Kg) tensile strength. No less than 24-in (600 mm) of slack shall be left at each end of the pull line. Attach a tag approved for the purpose to ends of pull line with nylon string and marked in indelible ink with location of other end and service for which conduit is provided.
- Q. Fire Alarm System conduits and raceways shall have junction box covers painted red and labeled "FIRE ALARM" in white letters.

3.4 CONDUIT - INSTALLATION

- A. Drawings indicate, generally, routes of branch circuits. Runs to panels are indicated as starting from nearest outlet. Provide conduits to panels as though routes were indicated in their entirety.
- B. Subcontractor shall not commence installation of conduits until conduit runs have been accounted for and properly planned.
- C. Conduits shall be continuous from panels to distributing centers, outlets, or switches. Pull boxes and splice boxes shall be installed where shown and where otherwise required to facilitate installation of conductors and to comply with code requirements. Different types of conduits shall not be intermixed in run.
- D. Conduits shall be installed to be free of traps, where condensation water could accumulate.
- E. When required for ease of cable pulling and as necessary to meet code, provide malleable conduit fittings or pull boxes even though not shown. Turns shall consist of malleable fittings or concentric bends.
- F. Bends and offsets shall be avoided where possible, but where necessary, shall be made with an approved one shot bender or conduit-bending machine. Make bends and offsets of as large a radius as construction will permit so as not to damage the conduit. Conduit bends shall not be kinked and shall not be flattened more than 5 percent of the outside diameter of the conduit. Where exposed conduits are run in groups, bends shall have a common center, with minimum inner radius eight times inside diameter of conduit. Standard elbows are not allowed at these locations.
- G. The use of 3/4 in (21 mm) conduit is permitted for the following.
 - 1. Lighting switch legs where there are not more than 6 conductors.
 - 2. EMCS/FMCS and other Class 2 or 3 control and signal wiring.
- H. The use of flexible conduit is restricted. Flexible conduit is not permitted in walls, above inaccessible ceiling spaces or within other concealed or inaccessible spaces. A bare

equipment grounding conductor shall be installed in conduit runs having a length of flexible metallic conduit, liquid-tight flexible metal conduit, or non-metallic conduit as part of the run. Liquid-tight flexible metal conduit shall be used in damp or wet locations requiring flexible conduit.

1. Flexible metal conduit or liquid-tight flexible metal conduit is permitted for final connection to transformers, rotating or vibrating equipment. The length of size or type flexible conduit shall not exceed 3-ft (900 mm) for this purpose.
 2. Flexible metal conduit or liquid-tight flexible metal conduit to sensors on piping shall not exceed 4-ft (1200mm).
 3. Above suspended ceilings, flexible metal conduit, 3/8-in trade size minimum, is permitted for final connection from the above ceiling outlet box to the light fixture. Flexible metal conduit to light fixtures shall not exceed 6-ft (1800 mm).
- I. Plug or cap unused conduit openings with a suitable device designed for the purpose. Caulking compound shall not be used for plugging conduit openings. Plug conduit with approved firestop material where conduits leave heated area and enter unheated area.
- J. Provide escutcheon plates at exposed wall, ceiling, and floor conduit penetrations. Provide prime painted split escutcheons where exposed conduits enter walls, ceilings, or floors in finished rooms. Use Crane Co. No. 10 BC, Grinnel, or equal.
- K. Underground stub-ups shall use wrapped or PVC-coated rigid steel galvanized 90-degree elbows with a minimum radius not less than that permitted by Code or as noted on the Drawings and wrapped or PVC-coated rigid steel galvanized conduit riser.
- L. Flash and counter flash conduits through roof.
- M. Penetrations (Where not cast-in place):
1. Pack space between conduit and hole in walls and floors with approved firestop materials for water and airtight seal.
 2. Make penetrations through walls and floors watertight with approved firestop materials, even though concealed within walls or furred space.
 3. Make penetrations through damp proofed/waterproofed surfaces by appropriate means to maintain integrity of system penetrated, including penetrations caused by hangers suspended off such surfaces.
 4. After the conduit is installed, the packed opening shall be painted to match the adjacent surface.
- N. Penetrations through Concrete: Provide galvanized rigid steel nipples threaded both ends before concrete is poured. Each end of nipples shall extend 3-in beyond wall or floor surfaces.
1. Provide standard pipe caps on each end of each empty nipple.

2. Where conduit of smaller size than nipple or individual cables pass through nipples, pack annular space with fire-inert material, for a minimum depth of 2-in (50 mm) each side or 3-in (75 mm) on one side.
 3. Where grout is noted provide Dry Wall Products, Inc. "Waterplug", U.S. Grout Corp., or equal, mixed, and placed in accordance with manufacturer's instructions and 3-in (75 mm) minimum depth.
- O. Rigid Metal Conduit: Connect with threaded ends, fully threaded couplings, thread into integrally cast hubs or use double locknuts and insulating bushings. Threadless fittings are not acceptable.
 - P. Electrical Metallic Tubing: Connect with compression type connectors and couplings.
 - Q. Rigid steel conduit to EMT connection shall consist of EMT connector and threaded rigid conduit coupling.
 - R. Where rigid steel conduit is installed in concrete slab on grade provide 3-in (75 mm) minimum thickness concrete encasement below conduit, tape wrap conduit with two layers of half-lapped 10-mil thick, black virgin vinyl polyethylene tape or factory-applied epoxy or PVC coating.
 - S. Keep conduits closed and moisture-tight during construction.
 - T. Conduit runs across roofs shall be supported [on redwood stand-off supports not less than 6-in (150 mm) nor more than 8-in (200 mm) above the roof surface, and at intervals not greater than 8-ft (2.4 m). The supports shall be set in asphalt on tar roofs or other roofs where asphalt is a compatible agent, or shall be securely fastened to the roof with an appropriate roofing adhesive material on roofing materials where asphalt is not a compatible material.
 - U. Conduit systems used for telephone/data system cabling shall not have more than a sum of 270-degree of bends between pull boxes, outlet boxes or termination closets. Condulet fittings shall not be used in such conduit systems.
 - V. No conduit shall be installed exposed on floor in areas except when approved by the project design engineer or inspector.
 - W. Conduit type or size indicated on drawings are to supersede specifications listed in this document, Section 26 05 43 – Raceways.

3.4.1 UNDERGROUND CONDUIT INSTALLATION

- A. Depth of conduit shall be 30-in (760 mm) minimum to top of conduit. Where interference with other underground work occurs, conduits shall pass below the other work.
- B. Grade conduits uniformly to drain to manholes.

- C. Wrap direct-buried galvanized steel conduit with two layers of half-lapped 10-mil thick, black virgin vinyl polyethylene tape or factory-applied epoxy or PVC coating. In either case, exposed threads, or damage to coating or tape shall be repaired prior to backfilling.
- D. Conduit systems, to be occupied by communications conductors, shall be separated from power distribution conduits by 24-in (600 mm) of well-tamped earth.
- E. Conduit Route Marking:
 - 1. To safeguard the conduits below, mark the route of direct-buried conduits using continuous warning tape buried in the trench above the conduits.
 - 2. In unpaved areas, bury the tape in the trench 12-in (300 mm) below the surface. In paved areas, install the tape in the trench just below the pavement section.
 - 3. Take necessary precautions to ensure that the warning tape is not pulled, distorted, or otherwise misplaced during backfilling.
- F. Add magnetic #10AWG tracer wire top of the underground non-metallic conduits or duct banks. The tracer wire shall be continuous along the path of the duct banks and conduit stub ups and shall be exposed in the manholes and at each stub up with minimum of 24-in (600 mm) pigtail in an embedded concrete box.
- G. Duct spacers shall be used to install ducts for maintaining duct spacing during concrete pour. The spacers shall be tied together with the ducts and reinforcement bars to form one integrated assembly.

3.5 GROUNDING

- A. Permanently and effectively ground conduit systems in accordance with Section 26 05 26 - Grounding. Grounding type bushing shall be grounded with the equipment ground wire.
- B. A separate ground conductor shall be run in each conduit and shall be connected to each junction box using a grounding screw in each box. An equipment bonding jumper shall be used to connect grounding type receptacles to the grounded box. The use of looped wires under grounding screws shall not be permitted.

3.6 INTERFACE WITH OTHER SYSTEMS

- A. Install conduit to preserve fire resistance rating of partitions and other elements.
- B. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket.

3.7 CONNECTIONS

- A. For motors, wall- or ceiling-mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:

1. Conduit Size 4-in or Less: Flexible, liquid-tight conduit
 2. Conduit Size Over 4-in: Nonflexible
 3. Wet or Corrosive Areas: Flexible, nonmetallic, or flexible metal liquid-tight
 4. Dry Areas: Flexible, metallic liquid-tight
 5. Length: 18-in minimum, 60-in maximum, sufficient to allow movement or adjustment of equipment
- B. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oil-Tight and Dust-Tight: Flexible metal, liquid-tight conduit.
- C. Transition From Underground or Concrete Embedded to Exposed: Rigid galvanized steel conduit wrapped for corrosion.
- D. Under Equipment Mounting Pads: Rigid galvanized steel conduit.

3.8 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating using fire penetration seal as approved by OWNER.
- D. Apply single layer of wraparound duct band to all metallic conduit protruding through concrete floor slabs to a point 2-in above and 2-in below concrete surface.
- E. Concrete Walls, Floors, or Ceilings (Above ground): Provide non-shrink grout dry-pack, or use watertight seal device.
- F. Entering Structures:
1. General: Seal raceway at the first box or outlet with oakum or expandable plastic compound to prevent the entrance of gases or liquids from one area to another
 2. Concrete Roof or Membrane Waterproofed Wall or Floor:
 - a. Provide a watertight seal
 - b. Without Concrete Encasement: Install watertight entrance seal device on each side
 - c. With Concrete Encasement: Install watertight entrance seal device on the accessible side
 - d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges

- e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner
3. Heating, Ventilating, and Air Conditioning Equipment:
 - a. Penetrate equipment in area established by manufacturer
 - b. Terminate conduit with flexible metal conduit at junction box or conduit attached to exterior surface of equipment prior to penetrating equipment
 - c. Seal penetration with approved sealant
 4. Existing or Precast Wall (Underground): Core drill wall and install a watertight entrance seal device
 5. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
 - a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device
 - b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side
 6. Manholes and Handholes:
 - a. Metallic Raceways: Provide insulated grounding bushings
 - b. Nonmetallic Raceways: Provide bell ends flush with wall
 - c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown

3.9 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 ft. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze.
- C. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.10 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bending radius in conduits for fiber optic cables shall be not less than 20 times cable diameter or 15-in, minimum, whichever is larger.
- C. Install with symmetrical bends or cast metal fittings.

- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
- G. PVC Conduit:
 - 1. Bends 30-Degree and Larger: Provide factory-made elbows
 - 2. 90-Degree Bends: Provide rigid steel elbows, PVC coated where direct buried
 - 3. Use manufacturer's recommended method for forming smaller bends
- H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.11 EXPANSION/DEFLECTION FITTINGS

- A. Provide on all raceways at all structural expansion joints, and in long tangential runs.
- B. Provide expansion/deflection joints for temperature variation between 20 degrees F and 100 degrees F.
- C. Install in accordance with manufacturer's instructions.

3.12 PVC CONDUIT

- A. Solvent Welding:
 - 1. Provide manufacturer recommended solvent; apply to all joints
 - 2. Install such that joint is watertight
- B. Adapters:
 - 1. PVC to Metallic Fittings: PVC terminal type
 - 2. PVC to Rigid Metal Conduit or IMC: PVC female adapter
- C. Belled-End Conduit: Bevel the unbelled end of the joint prior to joining.

3.13 CABLE TRAYS

- A. Install in accordance with Application Information Section of NEMA VE 1.
- B. Provide accessories as necessary for a complete system.
- C. Install such that joints are not made at support brackets.

- D. Install horizontal section support brackets between support point and quarter point of tray span.
- E. Provide ceiling trapeze for all horizontal cable tray.
- F. Install support within 2 ft on each side of expansion joints and within 2 ft of fitting extremity.
- G. Provide expansion joints in accordance with NEMA VE 1 for 50 degrees F maximum temperature variation.
- H. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8-in in 10 ft and within a cumulative maximum of 1/2-in.
- I. Install vertical tray plumb within a tolerance of 1/8-in in 10 ft.
- J. Install without exposed raw edges.
- K. Maintain 12-in vertical separation between multi-tiered trays having a common support, and at all crossover locations.
- L. Provide bonding jumper at each expansion joint and adjustable connection.
- M. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

3.14 TERMINATION AT ENCLOSURES

- A. Cast Metal Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
- B. Nonmetallic Cabinets and Enclosures: Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
- C. Sheet Metal Boxes, Cabinets, and Enclosures:
 - 1. Rigid Galvanized Conduit:
 - a. Provide one lock nut each on inside and outside of enclosure
 - b. Install grounding bushing
 - c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure
 - d. Install insulated bushing on ends of conduit where grounding is not required
 - e. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs
 - f. Utilize sealing locknuts or threaded hubs on outside of NEMA 3R and NEMA 12 enclosures

- g. Terminate conduits at threaded conduit hubs at NEMA 4 and 4X boxes and enclosures
- 2. Electric Metallic Tubing: Provide gland compression, insulated connectors
- 3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors
- 4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors
- 5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector
- 6. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut
- D. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures:
 - 1. Terminate metal conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad
 - 2. Terminate PVC conduit entering bottom with bell end fittings

3.15 CONDUIT IDENTIFICATION TAGS

A. Conduit Identification Tags:

- 1. Identify all new or reused conduits with unique conduit designations. Conduit designations shall be as shown in Cable and Conduit Schedule or new designations approved by OWNER
- 2. Install at each terminus, near midpoint, and at minimum intervals of every 50-ft of exposed Raceway, whether in ceiling space or surface mounted.
- 3. Provide stainless steel tags with stamped lettering. Provide non-corrosive wire for attachment

3.16 PROTECTION OF INSTALLED WORK

- A. Protect products from moisture, corrosion, and physical damage during construction.
- B. Provide manufactured watertight and dust-tight seals over all conduit openings during construction.
- C. Touch up painted conduit threads after assembly to cover nicks or scars.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 26 05 00 Electrical Work, General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 26 05 00 Electrical Work, General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 08 00 - ELECTRICAL TESTING

PART 1 -- GENERAL

1.1 REQUIREMENTS

- A. Provide the services of qualified testing personnel or firm for inspection, calibration, and testing of all installed equipment to establish equipment conforms to requirements specified in these specifications and is ready for commissioning tests. The testing firm shall be an independent business entity, or other qualified electrical worker.
- B. Organize the tests such that all aspects of installed equipment are covered, including the interface to existing equipment.
- C. Submit reports of all tests performed, including test procedures, measurements taken, settings entered, conclusions and recommendations.

1.2 REFERENCES

- A. Testing shall be performed in accordance with the applicable test criteria and requirements included in the following list of standards:
 - 1. American National Standards Institute (ANSI):
 - C2 National Electrical Safety Code
 - 2. Institute of Electrical and Electronics Engineers (IEEE)
 - 3. National Electrical Manufacturers Association (NEMA)
 - 4. International Electrical Testing Association (NETA): Acceptance Testing Specifications (ATS) for Electrical Power Distribution Equipment and Systems.
 - 5. National Fire Protection Association (NFPA):
 - 70 National Electrical Code (NEC).
 - 70E Standard for Electrical Safety in the Workplace.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. Submit 10 days prior to performing inspections or tests:
 - 1. Qualifications of testing firm or individuals.
 - 2. Schedule for performing inspection and tests.
 - 3. List of references to be used for each test.

4. Test procedures to be used for all equipment and subsystems
 5. Equipment and materials inspection form(s) to be used.
 6. Individual device test forms to be used.
 7. Individual system test forms to be used.
- C. Test Report: Submit within 7 days after completion of test. Report shall include:
1. Executive Summary
 2. Test criteria or standards used
 3. Test instruments used, including calibration records
 4. Test sheets with tester's and witness' initials organized to cover the following subsystems:
 - Wiring and Conduit system
 - Control Panels
 - Field sensors
 - Motor Controls
 - Equipment Interconnections
 - Others
 5. Observation, summary, and recommendations

1.4 QUALIFICATIONS

- A. Test personnel shall be engineers and/or technicians routinely engaged in testing and inspecting of electrical equipment, installations, and systems.
- B. Test personnel certified by NETA or otherwise qualified and approved by OWNER.
- C. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.
- D. Test instrument calibration shall be in accordance with NETA ATS.

1.5 SEQUENCING AND SCHEDULING

- A. Perform inspection and electrical tests after equipment has been installed.

- B. Perform tests with apparatus de-energized whenever feasible.
- C. Inspection and electrical tests on energized equipment are to be:
 - 1. Scheduled with OWNER prior to de-energization.
 - 2. Minimized to avoid extended period of interruption to the operating plant equipment.
- D. Notify OWNER at least 48 hours prior to performing tests on energized electrical equipment.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

- A. Tests and inspection shall establish that:
 - 1. Electrical equipment is operational within industry and manufacturer's tolerances.
 - 2. Wiring is correctly labeled and terminations are correct.
 - 3. Equipment is suitable for energization.
 - 4. Installation conforms to requirements of Contract Documents and referenced industry standards.
 - 5. Manufacturers' settings have been correctly entered and equipment operation verified.
 - 6. Equipment is ready for commissioning tests in accordance with Division 01 – General Requirements.
- B. Perform inspection and testing in accordance with NETA Acceptance Testing Specifications, industry standards, and manufacturer's recommendations.
- C. Verify, test, and calibrate protective relays, circuit breakers, fuses, VFDs, motor starters, and other applicable devices.
- D. Adjust mechanisms and moving parts for free mechanical movement.
- E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
- F. Verify nameplate data for conformance to Contract Documents.
- G. Realign equipment not properly aligned and correct unlevelness.
- H. Properly anchor electrical equipment found to be inadequately anchored.

- I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.
- J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.
- K. Inspect raceways and busways for proper routing and support. Verify each raceway is properly identified with label.
- L. Verify cables and wiring are properly identified with circuit labels and conductor identifications.
- M. Investigate and repair or replace:
 - 1. Electrical or control items that fail tests.
 - 2. Active components not operating in accordance with manufacturer's instructions.
 - 3. Damaged electrical equipment.
- N. Electrical Enclosures and Panels:
 - 1. Remove foreign material and moisture from enclosure interior.
 - 2. Vacuum and wipe clean enclosure interior.
 - 3. Remove corrosion found on metal surfaces.
 - 4. Repair or replace door and panel sections having dented surfaces.
 - 5. Repair or replace poor fitting doors and panel sections.
 - 6. Repair or replace improperly operating latching, locking, or interlocking devices.
 - 7. Replace missing or damaged hardware.
 - 8. Finish:
 - a. Provide matching paint and touch up scratches and mars.
 - b. If required due to extensive damage, refinish the entire assembly.

3.2 WIRING AND CABLE TESTING

- A. Visual and Mechanical Inspections:
 - 1. Physical damage to jacket and insulation.
 - 2. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
 - 3. Proper support.

4. Color coding conformance with specifications.
5. Proper shield grounding.
6. Proper circuit identification.
7. Correct phasing and polarities.
8. Correct point-to-point terminations.
9. Proper lug type for conductor material.
10. Proper lug installation.
11. Proper clearances.
12. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

B. Insulation Resistance Tests:

1. Perform insulation resistance test using DC voltages per NETA ATS Table 100.1.
2. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures.
3. Investigate values less than shown in Table 100.1.
4. Continuity test by ohmmeter method to ensure proper cable connections.

C. Current and Voltage Application Tests:

1. Inject AC or DC test current, as applicable, to each current loop and confirm proper currents are measured at target devices.
2. Apply AC or DC test voltage, as applicable, and confirm proper voltage is received by target devices.

D. Operational Tests:

1. Initiate control devices.
2. Check proper operation of control system and VFDs.
3. Check alarms and shutdown circuits.

3.3 CONTROL PANELS AND DEVICES

A. Visual and Mechanical Inspection:

1. Verify that power supply and equipment grounding conductors are correctly provided in accordance with NEC.
2. Verify by point-to-point check that field wiring is correctly terminated with devices, sensors, switches, relays, interlocks, communication lines, PLCs, and other interfacing devices in accordance with the approved shop drawings.
3. Verify that low voltage signal wiring is correctly terminated and shields grounded.
4. Verify conductor labels and terminal identifications in accordance with shop drawings provided by manufacturers and suppliers.
5. Verify nameplate data.

B. Electrical Tests:

1. Verify and calibrate instrumentation input and output loops
2. Verify shutdown functions.
3. Verify proper inputs are received from field transducers and sensors.
4. Verify operation of control circuits by observing target field devices.
5. Verify Hand-Off-Auto and Manual-Off-Auto functions.

3.4 SENSORS AND TRANSDUCERS

A. Visual and Mechanical Inspection:

1. Verify devices against nameplate data.
2. Verify correct locations, polarity and orientation.
3. Verify integrity of installation.

B. Electrical Tests:

1. Verify sensors are correctly connected to power source.
2. Calibrate for linearity and output range.
3. Verify signal isolation with adjacent circuits.
4. Verify proper grounding of conductor shields

3.5 GROUNDING SYSTEM

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor controllers, panelboards, and switchgear assemblies for proper connection, continuity and tightness.
2. Ground bus connections in motor controllers, panelboards, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Verify interconnections to existing/added grounding scheme.

3.6 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check nameplates for proper identification of devices installed.
8. Verify performance of each control device and feature furnished as part of the motor controller.
9. Control Wiring:
 - a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
 - b. Check for proper conductor lacing and bundling.
 - c. Check for proper conductor identification.
 - d. Check for proper conductor lugs and connections.

B. Operational Tests:

1. Operate equipment by initiating controls from control station.
2. Check for correct rotation.
3. Verify HOA switch functions.

3.7 MISCELLANEOUS CIRCUITS AND DEVICES

- A. CONTRACTOR shall ensure that all other equipment supplied and installed under this Contract are properly installed, interconnected, and ready for operation whether or not they are specifically identified in this Section.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 26 05 00 Electrical Work, General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 26 05 00 Electrical Work, General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 31 00 00 - EARTHWORK

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall perform earthwork as indicated and required for construction of the WORK, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

- A. The CONTRACTOR shall submit samples of materials proposed for the WORK in conformance with the requirements of General Conditions Section 9 - Submittals. Sample sizes for materials testing shall be as required by the testing laboratory. Other sample sizes will be as prescribed by the OWNER or ENGINEER. CONTRACTOR shall coordinate with the OWNER and ENGINEER on timing and location of delivery of samples.
- B. CONTRACTOR's Detailed Excavation Plan
 - 1. The CONTRACTOR, prior to beginning any trench or structure excavation 5 feet deep or deeper, shall submit to the OWNER and shall be in receipt of the OWNER's written acceptance of the CONTRACTOR's detailed plan showing the design of shoring, bracing, sloping of the sides of excavation, or other provisions for worker protection against the hazard of caving ground during the excavation of such trenches or structure excavation.
 - 2. The CONTRACTOR's plan shall be prepared and signed and sealed by a Professional Engineer experienced in the field of geotechnical engineering and licensed in the State where the WORK is being performed.
 - 3. The OWNER's acceptance of said plan will be for verification of submittal of the plan with this requirement.
 - 4. If such plan varies from the shoring system standards established in the Construction Safety Orders of the State of California, such alternative systems plans shall be prepared by a civil or structural engineer licensed in the State of California.

PART 2 -- PRODUCTS

2.1 FILL AND BACKFILL MATERIAL REQUIREMENTS

A. General

- 1. Fill, backfill, and embankment materials shall be selected or shall be processed and contain clean fine earth, rock, gravel, or sand, free from grass, roots, brush, other vegetation and organic matter.
- 2. Fill and backfill materials that are to be placed within 6 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

B. Suitable Materials

1. Materials not defined below as unsuitable will be considered as suitable materials and may be used in fills, backfilling, and embankment construction, subject to the indicated requirements.
2. If acceptable to the ENGINEER, some of the material listed as unsuitable may be used when thoroughly mixed with suitable material to form a stable composite.
3. Mixing or blending of materials to obtain a suitable composite is the CONTRACTOR's option but is subject to the approval of the ENGINEER.
4. Suitable materials may be obtained from on-Site excavations, may be processed on-Site materials, or may be imported.
5. If imported materials are required by this Section or are required in order to meet the quantity requirements of the WORK, the CONTRACTOR shall provide the imported materials as part of the WORK.

C. Types of Suitable Materials. The following types of suitable materials are defined:

Type AS (Aggregate Subbase): Crushed rock aggregate subbase material that can be compacted readily by watering and rolling to form a firm stable base. This material is often specified and required underneath the base course of asphaltic or concrete pavement. At the option of the CONTRACTOR, the grading for either the 3-inch maximum size or 2-inch maximum size gradation shall be used. The sand equivalent value shall be greater than 20. Crushed rock aggregate subbase material shall meet one of the following gradation requirements, as shown on the Drawings or approved by the OWNER:

Sieve Size	Percentage Passing (3-inch Max)	Percentage Passing (2-inch Max)
3-inch	100	100
2.0 inch	90 - 100	100
1.5 inch	-	95 - 100
No. 4	30 - 65	30 - 65
No. 16	15 - 40	15 - 40
No. 200	0 - 20	0 - 20

Type C (Civil Fill) (Not for use beneath concrete foundations): Civil Fill may consist of imported materials or natural on-site materials. Civil Fill may be a combination of Type AS material, Type GF, or Type SF material, or any mixture thereof, except as

shown. Some mixing, removal of oversized particles (greater than 4-inch diameter) and/or removal of other unsuitable material may be required.

Type CP (Clay Plug / Trench Plug): Low permeable fill material, a non-dispersible clay material having a minimum plasticity index of 10.

Type DRC (Drain-rock Coarse): Crushed rock or gravel meeting the following gradation requirements.

Sieve Size	Percentage Passing
2-inch	100
1.5-inch	90 - 100
1-inch	20 - 55
3/4-inch	1 - 15
No. 200	0 - 3

Type DRG (Drain-rock Graded): Drain-rock shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The drainrock shall have a sand equivalent value greater than 75. The finish graded surface of the drainrock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs. The material shall be uniformly graded and shall meet the following gradation requirements:

Sieve Size	Percentage Passing
1-inch	100
0.75-inch	90 – 100
0.375-inch	40 – 100
No. 4	25 – 40
No. 8	18 – 33
No. 30	5 – 15
No. 50	0 – 7
No. 200	0 – 3

The finish graded surface of the drain rock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs.

Type EF (Embankment Fills from on-Site materials): Embankment Fill may be obtained from on-Site excavations, may include processed on-Site materials, or may be imported materials comprising mixtures of Type AS or Type SF material. If on-Site material is used for embankments, it may require moisture conditioning to facilitate compaction. Drying of the embankment fill material may not be practical during cold or wet periods of the year. Acceptable embankment material shall meet or exceed the compaction density of 95 percent as determined by ASTM D-1557.

Type ESM - Engineered Streambed Material: As defined per California Department of Fish and Wildlife Fish Passage Design and Implementation Part XII (CDFW XII) Engineered Streambed Material (ESM) 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. 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.

Existing streambed boulders within the Project boundary and clearing limits meeting the definition set forth in the CDFW XII rock size shall be collected, stockpiled and reused for this Project.

Rock Class	Percent by Volume	Percent Passing	Diameter (in)	Installation Method (3.6.C)
A	8	92	42-35	A
B	7	85	24-35	A
C	7	78	18-24	A
D	10	68	9-18	A
E	18	50	9-18	B
F	34	16	2-9	B
G	8	8	2mm-2in	B
H	8	0	<2mm	B

Type GF (Granular Fill 0.75-inch minus): Angular crushed rock, stone or gravel, and sand conforming to the requirements listed below. Do not use pea gravel as granular backfill: The material shall have a maximum liquid limit of 35 and a maximum plasticity index of 10. The material shall have a sand equivalent value greater than 75. (This material is also known as Class I crushed stone.)

Sieve Size	Percentage Passing
0.75-inch	100
No. 4	30 - 50
No. 200	0 - 6

Type PG (Pea Gravel fill): Crushed rock or gravel with 100 percent passing a 1/2-inch sieve and not more than 10 percent passing a Number 4 sieve.

Type SF (Structural Fill / Foundation Base): Crushed rock structural fill material of such nature that it can be compacted readily by watering and rolling to form a firm, stable base for fill material required beneath concrete foundations. This material is often specified and required directly underneath the finish course of asphaltic or concrete pavement. At the option of the CONTRACTOR, the grading for either the 1.5 inch maximum size or 0.75-inch maximum size gradation may be used material beneath concrete foundations. The sand equivalent value shall be greater than 22. The material shall meet the following gradation requirements:

Sieve Size	Percentage Passing	
	1.5 inch Max Gradation	0.75-inch Max Gradation
2-inch	100	-
1.5-inch	90 - 100	-
1-inch	-	100
0.75-inch	81 - 91	90 – 100
No. 4	43 - 53	55 – 67
No. 16	23 - 29	28 – 38
No. 200	4 - 10	4 – 10

Type T (Topsoil): Stockpiled topsoil material which has been obtained at the Site by removing soil to a depth not exceeding 2 feet. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris.

Schedule: Earth materials shall be as indicated in the Contract Drawings. Where clear definition in the drawings is not defined, the following schedule may be used to define acceptable fill materials.

Civil Work Area	Material Type
Roughened Rock Channel	ESM
Embankment Fills – (Solids Settling Basins & other Embankments)	Type EF material, or Mixture of AS thru GF materials that meet Type EF gradation requirements.
Pipe Zone (unless indicated as Trench Zone)	
Small PVC (< 6-inch dia), HDPE (ADS) Drain Pipe, & other pipes < 3-inch dia.	GF, SF
Other PVC, VCP, HDPE Pipe	GF
Trench zone backfill except as identified below	C, EF or an approved mixture thereof.
Final backfill for irrigated unpaved areas	T
Trench zone and final backfill under structures	Same as pipe zone except where concrete encasement is required
Asphalt & Concrete Pavement Aggregate base & Gravel Road base materials	DRG
Asphalt & Concrete Pavement Aggregate subbase & Gravel Road subbase materials	AS
Backfill around structures (including berms)	C, EF, or an approved mixture

D. Unsuitable Materials.

1. Soils which, when classified under ASTM D 2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System), fall in the classifications of PT, OH, CH, MH, or OL shall be classified as unsuitable materials.
2. In addition to the materials identified as unsuitable in the table above, a material shall be classified as unsuitable if one of the following conditions is present;

- a. Soils which cannot be compacted sufficiently to achieve the density specified for the intended use.
- b. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, and any material which may be classified as hazardous or toxic according to applicable regulations.

2.2 MATERIALS TESTING

A. Samples

1. Soils testing of samples submitted by the CONTRACTOR will be performed by a testing laboratory of the OWNER's choice and at the CONTRACTOR's expense.
2. The ENGINEER may direct the CONTRACTOR to supply samples for testing of any material used in the WORK.

B. **Particle Size Analysis.** Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils.

C. **Sand Equivalent Value.** Determination of sand equivalent value will be performed using ASTM D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System

1. References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487.
2. The CONTRACTOR shall be bound by applicable provisions of ASTM D 2487 in the interpretation of soil classifications.

2.3 IDENTIFICATION TAPE

- A. Unless otherwise indicated, identification tape shall be placed above buried pipelines that are not comprised of magnetic components at least in part.
- B. Identification tape shall be 6-inches wide, yellow in color, composed of polyethylene, and provided with an integral metallic wire.
- C. Tape shall be labeled with CAUTION – BURIED UTILITIES.

PART 3 -- EXECUTION

3.1 EXCAVATION AND BACKFILLING - GENERAL

A. General

1. Except when specifically provided to the contrary, excavation shall include the removal of materials, including obstructions that would interfere with the proper execution and completion of the WORK.

2. The removal of such materials shall conform to the lines and grades indicated or ordered.
3. Unless otherwise indicated, the entire Site shall be stripped of vegetation and debris and shall be grubbed to the lines and limits shown on the Drawings, and such material shall be removed from the Site prior to performing any excavation or placing any fill.
4. The CONTRACTOR shall furnish, place, and maintain supports and shoring that may be required for the sides of excavations.
5. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable state safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).
6. The CONTRACTOR shall provide quantity surveys where so required to verify quantities for Unit Price Contracts.
7. Surveys shall be performed prior to beginning WORK and upon completion by a surveyor licensed in the state where the Site is located.

B. Removal and Exclusion of Water

1. The CONTRACTOR shall remove and exclude water, including stormwater, groundwater, irrigation water, and wastewater, from excavations.
2. Dewatering wells, wellpoints, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation WORK begins at each location.
3. Water shall be removed and excluded until backfilling is complete and field soils testing has been completed.

3.2 OVER-EXCAVATION

A. **Indicated**

1. Where areas are indicated to be over-excavated, excavation shall be to the depth indicated, and backfill shall be installed to the grade indicated.

B. **Not Indicated**

1. When ordered to over-excavate areas deeper and/or wider than required by the Contract Documents, the CONTRACTOR shall over-excavate to the dimensions ordered and backfill to the indicated grade.

C. **Neither Indicated nor Ordered**

1. Any over-excavation carried below the grade that is neither ordered or indicated shall be backfilled and compacted to the required grade with the indicated material as part of the WORK.

3.3 EXCAVATION IN VICINITY OF TREES

- A. Except where trees are indicated to be removed, trees shall be protected from injury during construction operations. This includes avoiding or otherwise protecting the crown and root system of the trees.
- B. No tree roots larger than 2 inches in diameter shall be cut without the express permission of the ENGINEER.
- C. Trees shall be supported during excavation by any means previously reviewed and accepted by the ENGINEER.

3.4 ROCK EXCAVATION

- A. **Normal Excavation.** Nearly all excavation, except where indicated in the Contract Drawings, shall be considered normal excavation, and may be accomplished using conventional equipment as follows:
 - 1. For general excavation, a D-9N Caterpillar tractor with a single shank ripper, or equivalent equipment, is considered conventional equipment, if it can rip at a production rate of at least 300 bank cubic yards per hour.
 - 2. For trench excavation, a 235C Caterpillar excavator with a medium stick and a rock ripping bucket, or equivalent equipment, is considered conventional equipment, if it can excavate at a production rate of at least 30 bank cubic yards per hour.
 - 3. If material is encountered which the CONTRACTOR believes cannot be excavated by conventional equipment, the ENGINEER shall be notified immediately. The CONTRACTOR shall provide performance tests of the specified conventional or equivalent equipment. If the ENGINEER confirms in writing that the conventional equipment cannot perform at the production rates indicated, the excavation will be considered rock excavation.
- B. **Rock Excavation.** Rock excavation shall include removal and, as appropriate, reuse or disposal of the following items:
 - 1. Boulders measuring 1/3 of a cubic yard or more in volume;
 - 2. Rock material in ledges, bedding deposits, and un-stratified masses that cannot be removed using conventional equipment as defined herein and which require systematic drilling and blasting for removal;
 - 3. Concrete or masonry structures that have been abandoned; and,
 - 4. Conglomerate deposits that are so firmly cemented that they possess the characteristics of solid rock and cannot be removed using conventional equipment as herein defined and require systematic drilling and blasting for removal.

C. Scope and Payment for Rock Excavation

1. Rock excavation shall be performed by the CONTRACTOR, provided that if the quantity of rock excavation is affected by any change in the scope of the WORK an appropriate adjustment of the Contract Price will be made. Payment for rock excavation shall be as set forth in the Bid form as a unit price item. If a unit price item for rock excavation is not provided in the Bid form, the extra cost for excavation of rock will be treated as a change.
2. Otherwise, payment will be made in accordance with a negotiated price.

D. Explosives and Blasting. Blasting will not be permitted on the project site.

3.5 DISPOSAL OF EXCESS EXCAVATED MATERIAL

- A. Unless otherwise indicated, excess excavated material shall be the property of the CONTRACTOR.
- B. The CONTRACTOR shall be responsible for the removal and disposal of excess excavated material.
- C. The CONTRACTOR shall remove and dispose of excess excavated material at a location selected by the CONTRACTOR and as approved by the ENGINEER or at an off-Site location selected and arranged for by the CONTRACTOR.
- D. The CONTRACTOR shall obtain required permits and landowner and agency approvals for disposal of excess excavated material on-Site or off-Site and shall submit copies of related documents to the ENGINEER for information prior to disposal. CONTRACTOR shall pay costs associated with the removal and disposal

3.6 BACKFILL

This section includes requirements for pre-placement conditions and placement of the roughened channel, in addition to other areas of backfill.

A. General

1. Backfill shall not be dropped directly upon any structure or pipe.
2. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed.
3. Backfill around water-retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed.

B. Pre-Placement Conditions

1. Except for drainrock materials being placed in over-excavated areas or trenches, backfill shall not be placed until water is removed from the excavation and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction

2. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have any loose, sloughing, or caving soil and rock materials removed.
3. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

C. **Rock Placement**

1. Method A – Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing of rocks by dumping will not be permitted. Local surface irregularities of the slope protection shall not vary from the planned slope by more than 0.3-m measured at right angles to the slope.
2. Method B – Rocks may be placed by dumping and may be spread in layers by suitable equipment.

D. **Layering**

1. Engineered Streambed Material (ESM) shall be placed in layers no thicker than 1-foot and compacted using either flooding and/or jetting methods. Stones larger than the lift height shall be individually placed throughout the channel, followed by placement and mixing of the remaining portion of the ESM. Exposed stones shall not protrude more than 1/3 of its height above the finished channel grade.
2. Backfill materials shall be placed and spread evenly in layers. During spreading, each layer shall be thoroughly mixed as necessary in order to promote uniformity of material in each layer.
3. When compaction is achieved using mechanical equipment, the layers shall be evenly spread such that when compacted each layer shall not exceed 6 inches in thickness.

E. **Flooding and Jetting Methods.** When compaction is achieved using flooding and jetting methods, each layer shall not exceed 1 foot in thickness after compaction.

1. Engineered Streambed Material (ESM) shall be compacted by a combination of flooding and/or jetting if the CONTRACTOR uses effective procedures that achieve the required compaction test results. Fines shall be considered to have adequately filled the voids between larger materials when flooding each lift results in ponding of water above said compacted lift.
2. CONTRACTOR shall perform a test placement of cobbles and fines for OWNER's approval to determine the correct ratio of cobbles to fines for the ESM. If, after the test placement, ponding occurs after flooding and jetting fines into the cobble mixture, the proportion shall be considered acceptable and approved material ratios

shall be used throughout the project. If ponding does not occur, the mix proportions shall be adjusted, and testing repeated until ponding occurs.

3. Flooding and jetting shall not be performed in such a manner that utilities are damaged, in areas of poorly draining or expansive soils, or where the use of the procedure is prohibited by any agency having jurisdiction over the street or right-of-way.
4. Approved jet pipes or immersible vibrators shall be used such that each backfill layer is saturated and consolidated to its full depth before the next layer is placed.

F. Moisture Content

1. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.
2. Where the backfill material moisture content is too high to permit the indicated degree of compaction, the material shall be dried until the moisture content is satisfactory.

3.7 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION AND BACKFILL

A. Excavation Beneath Structures and Embankments

1. Except where indicated otherwise for a particular structure or where ordered by the ENGINEER, excavation shall be carried to an elevation 6 inches below the bottom of the footing or slab and brought back to grade with compacted materials acceptable for placement beneath structures.
2. The area where a fill or embankment is to be constructed shall be cleared of vegetation, roots, and foreign material.
3. Where indicated or ordered, areas beneath structures or fills shall be over-excavated.
4. The subgrade areas beneath embankments shall be excavated to remove not less than the top 6 inches of native material and where such subgrade is sloped, the native material shall be benched.
5. When such over-excavation is indicated, both the over-excavation and the subsequent backfill to the required grade shall be performed by the CONTRACTOR.
6. After the required excavation or over-excavation for fills and embankments has been completed, the exposed surface shall be scarified to a depth of 6 inches, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

B. Excavation Beneath Paved Areas

1. Excavation under areas to be paved shall extend to the bottom of the aggregate base or subbase, if such base is called for; otherwise it shall extend to the paving thickness.
2. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.
3. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement.
4. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

C. Notification of ENGINEER

1. The CONTRACTOR shall notify the ENGINEER at least 3 Days in advance of completion of any structure or roadway excavation and shall allow the ENGINEER a review period of at least one day before the exposed foundation is scarified and compacted or is covered with backfill or with any construction materials.

D. Compaction of Fill, Backfill, and Embankment Materials

1. Each layer of backfill materials as defined herein, where the material is graded such that 10 percent or more passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density.
2. Equipment that is consistently capable of achieving the required degree of compaction shall be used, and each layer shall be compacted over its entire area while the material is at the required moisture content.
3. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of obtaining the required density in 2 passes.

E. Heavy Equipment

1. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the vertical depth of the fill above undisturbed soil at that time.
2. Hand-operated power compaction equipment shall be used where the use of heavier equipment is impractical or restricted due to weight limitations.

F. Layering

1. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers.
2. Each layer shall be moistened and aerated as necessary.

3. Unless otherwise approved by the ENGINEER, no layer shall exceed 6 inches of compacted thickness.
4. The embankment and fill shall be compacted in conformance with Paragraph K, below.

G. Embankments and Fills on Slopes

1. When an embankment or fill is to be constructed and compacted against hillsides or fill slopes steeper than 4:1, the slopes of the hillsides or fills shall be horizontally benched in order to key the embankment or fill to the underlying ground.
2. A minimum of 12 inches perpendicular to the slope of the hillside or fill shall be removed and re-compacted as the embankment or fill is brought up in layers.
3. Material thus cut shall be re-compacted along with the new material.
4. Hillside or fill slopes 4:1 or flatter shall be prepared in accordance with Paragraph A, above.

H. Compaction Requirements

1. The following compaction requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft³) (2,700 kN-m/m³) where the material is graded such that 10 percent or more passes a No. 4 sieve and in accordance with ASTM D 4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density, where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve:

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Embankments and fills not identified otherwise	90	55
Embankments and fills beneath paved areas or structures	95	70
Backfill beneath structures and hydraulic structures	95	70
Backfill on reservoir of structure roof	90	55
Topsoil	80	NA
Aggregate base or subbase	95	NA

3.8 PIPELINE AND UTILITY TRENCH EXCAVATION AND BACKFILL

A. General

1. Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with minimum widths as indicated.

B. Trench Bottom

1. Except where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe.
2. Excavations for pipe bells and welding shall be made as required.
3. Where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe bedding.

C. Open Trenches

1. The maximum amount of open trench permitted in any one location shall be 500 feet or the length necessary to accommodate the amount of pipe installed in a single Day, whichever is greater.
2. Trenches shall be fully backfilled at the end of each Day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting vehicular traffic in those locations where it is impractical to backfill at the end of each Day.
3. These requirements for backfilling or use of steel plate will be waived in cases where the trench is located further than 100 feet from any traveled roadway or occupied structure; in such cases, however, barricades and warning lights meeting appropriate safety requirements shall be provided and maintained.

D. Embankments, Fills and Structural Backfills

1. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.
2. Upon completion of the embankment or structural backfill, a trench conforming to the appropriate detail may be excavated and the pipe may be installed.

E. Trench Shield

1. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield such that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls and causing sloughing or caving of the trench walls.
2. If the trench walls cave or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally.
4. The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

F. Placing and Spreading of Backfill Materials

1. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of achieving the required density in 2 passes and that is acceptable to the ENGINEER.
2. Where such materials are used for pipe zone backfill, vibratory compaction shall be used at vertical intervals of the lesser of one-half the diameter of the pipe; or 24 inches, measured in the uncompacted state.
3. In addition, these materials shall be subjected to vibratory compaction at the springline of the pipe and the top of the pipe zone backfill, regardless of whether that dimension is less than 24 inches or not.
4. Each layer of backfill material with greater than 10 percent passing the No. 4 sieve shall be compacted using mechanical compactors suitable for the WORK.
5. The material shall be placed and compacted under the haunch of the pipe and up each side evenly so as not to move the pipe during the placement of the backfill.
6. The material shall be placed in lifts that will not exceed 6 inches when compacted to the required density.

G. Flooding and Jetting

1. Pipeline trench zone backfill materials containing 5 percent or less of material passing a No. 200 sieve may be compacted using flooding and jetting or vibration if the CONTRACTOR uses effective procedures that achieve the required compaction test results.
2. Flooding and jetting shall not be performed in such a manner that the pipe or nearby utilities are damaged, in areas of poorly draining or expansive soils, or where the use of the procedure is prohibited by any agency having jurisdiction over the street or right-of-way.
3. Approved jet pipes or immersible vibrators shall be used such that each backfill layer is saturated and consolidated to its full depth before the next layer is placed.
4. Jet pipes shall be kept at least 6 inches away from the pipe where the backfill is being consolidated and 2 feet away from other pipes or utilities.

H. Mechanical Compaction

1. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand-operated vibratory compactors and rollers that do not damage the pipe.
2. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

I. Pipe And Utility Trench Backfill

1. Definitions
 - a. **Bedding.** The bedding is defined as that portion of pipe zone backfill material between the trench subgrade and the bottom of the pipe.
 - b. **Pipe Zone.** The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane below the bottom surface of the pipe and a plane at a point above the top surface of the pipe as indicated.
 - c. **Trench Zone.** The trench zone (located above the pipe zone) is defined as that portion of the vertical trench cross-section lying as indicated between a plane above the top surface of the pipe and a plane at a point 18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the roadway subgrade.
 - d. **Final Backfill.** Final backfill is defined as backfill in the trench cross-sectional area within 12 inches of finished grade, or if the trench is under pavement, backfill within 18 inches of the roadway subgrade.
2. Pipe Zone Backfill
 - a. Final Trim
 - 1) After compacting the bedding, the CONTRACTOR shall perform a final trim using a stringline for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe.
 - 2) Excavation for pipe bells and welding shall be made as required.
 - b. The pipe zone shall be backfilled with the indicated backfill material.
 - c. Pipe zone backfill materials shall be manually spread evenly around the pipe, maintaining the same height on both sides of the pipe such that when compacted the pipe zone backfill will provide uniform bearing and side support.
 - d. The CONTRACTOR shall exercise care in order to prevent damage to the pipeline coating, cathodic bonds, and the pipe itself during the installation and backfill operations.

3. Trench Zone Backfill

- a. After the pipe zone backfill has been placed, backfilling of the trench zone may proceed.

J. Identification Tape

- 1. Install identification tape as indicated.
- 2. Terminate the tape in a precast concrete box either adjacent to or part of the valve box, manhole, vault, or other structure into which the non-metallic pipe enters or at the end of the non-metallic pipeline.
- 3. The termination box shall be covered with a cast iron lid.
- 4. The box shall be located at grade in paved areas or 6 inches above grade in unpaved areas.

K. Trench Shield

- 1. If a moveable trench shield is used during backfill operations, the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer.
- 2. The CONTRACTOR shall not displace the pipe or backfill while the shield is being moved.

L. Compaction Requirements

- 1. The following compaction test requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft³) (2,700 kN-m/m³) where the material is graded such that 10 percent or more passes a No. 4 sieve, and in accordance with ASTM D 4253 - Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve.

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Pipe embedment backfill for flexible pipe.	90	70
Pipe bedding and over-excavated zones under bedding for flexible pipe, including trench plugs.	90	70
Pipe embedment backfill for steel yard piping	---	70

Pipe zone backfill portion above embedment for flexible pipe	90	55
Pipe embedment backfill for rigid pipe	90	55
Pipe zone backfill portion above embedment for rigid pipe.	90	55
Pipe bedding and over-excavated zones under bedding for rigid pipe.	90	70
Final backfill, beneath paved areas or structures.	95	70
Final backfill, not beneath paved areas or structures.	85	55
Trench zone backfill, beneath paved areas and structures, including trench plugs.	90	70
Trench zone backfill, not beneath paved areas or structures, including trench plugs.	90	70

3.9 FIELD TESTING

A. General:

1. Field soils testing will be performed by a testing laboratory of the OWNER's choice at the OWNER's expense, except as indicated below.

B. Density

1. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557.
2. Where cohesionless, free draining soil material is required to be compacted to a percentage of relative density, the calculation of relative density will be determined in accordance with ASTM D 4253 and D 4254.
3. Field density in-place tests will be performed in accordance with ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method, ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place By Nuclear Methods (Shallow Depth), or by such other means acceptable to the ENGINEER.

C. Remediation

1. In case the test of the fill or backfill shows non-compliance with the required density, the CONTRACTOR shall accomplish such remedy as may be required to ensure compliance.
2. Subsequent testing to show compliance shall be by a testing laboratory selected by the OWNER and paid by the CONTRACTOR.

D. CONTRACTOR's Responsibilities

1. The CONTRACTOR shall provide test trenches and excavations, including excavation, trench support and groundwater removal for the OWNER's field soils testing operations.
2. The trenches and excavations shall be provided at the locations and to the depths as required by the OWNER.
3. Lawn areas destroyed by test trenching and excavation shall be regraded and landscaped with hydroseeding.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as the cubic yards (CY) of the various types of soil, all of which have been completely placed or excavated.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the placement or removal of soil as shown on the Construction Drawings, or as designated in Section 31 00 00 – Earthwork. The concrete seal, foundation rock or coarse aggregate when used as directed in unstable material will be paid for at the unit price bid per cubic yard, which shall be full payment for all excavation and removal of unsuitable material and furnishing, placing and compacting the foundation rock, coarse aggregate or other approved material all complete in place. A description of work is included at the start of this section. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 31 03 10 - DIVERSION AND CARE OF STREAM DURING CONSTRUCTION

PART 1 -- GENERAL

1.1 SUMMARY

- A. Constructing and maintaining cofferdams, bladder dams, sheet pile cutoff walls, channels, flumes, drains, sumps, and other temporary diversion, unwatering and protective works in and immediately adjacent to Auburn Ravine.
- B. Removing or leveling such works, where required.
- C. Disposing of materials.
- D. Diverting the stream or unwatering areas of the stream that would otherwise be inundated during construction.
- E. Other work required by this Section.

1.2 CONTRACTOR SUBMITTALS

- A. Submit the following in accordance with the requirements of General Conditions Section 9 – Submittals.
- B. Water Control Plan:
 - 1. Deliver Water Control Plan at least 30 days prior to beginning any work on the diversion and care of the stream.
 - 2. Water Control Plan to be approved by CONTRACTING OFFICERS REPRESENTATIVE (COR) and ENGINEER prior to commencing any work on the diversion and care of the stream.
 - 3. Describe proposed method for diversion and/or unwatering and care of stream during construction and measures to be taken to meet permit requirements.
 - 4. Describe care of stream throughout construction activities, including but not limited to:
 - a. Control and prevention of aquatic invasive species within the work area;
 - b. Use of environmentally benign oils and lubricants;
 - c. Other Best Management Practices to ensure the protection of the aquatic environment.
 - 5. Describe proposed method for delivering water to Hemphill Canal during the construction period.
 - 6. The water control plan shall contain no more than four (4) major divisions of work for diversion and care of stream during construction.

- a. Outline and identify each major division by title.
- b. Allocate a proportionate part of the lump-sum price to each major division of work of the water control plan. The price allocation is subject to COR approval.

1.3 SITE CONDITIONS

A. Hydrographs and Discharge Curves:

1. Hydrographs of Auburn Ravine below the existing Hemphill Diversion Structure are available from NID and may be used solely for information of the CONTRACTOR in timing construction operations to prepare for such flood storage or flow bypassing as may be necessary.
2. Design discharges in Auburn Ravine at the Project site are provided in the drawing set and may be used solely for information of the CONTRACTOR in timing construction operations to prepare for such flood storage or flow bypassing as may be necessary.
3. The COR assumes no responsibility for deductions, interpretations, or conclusions made by the CONTRACTOR based on information made available by the COR.

B. Hemphill Canal Flows:

1. Continual flow shall be provided for Hemphill Canal throughout the irrigation season. Hemphill Canal flow shall be determined by Nevada Irrigation District staff (typical range: 3cfs – 8 cfs).

C. Environmental and Regulatory Requirements:

1. Do not interrupt or interfere with the natural flow of Auburn Ravine downstream of the Project site for any purpose or reason without the prior written approval of the COR.
2. All work efforts related to diversion and care of streams shall conform to the stipulations provided in the permitting documents, including all federal, state, tribal and local permits obtained for the Project.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 PROTECTION

- A. Remove rock fragments, lumber, metal, and other solid debris materials at the location of unwatering prior to diversion and prevent such materials from being mobilized and washed downstream.

3.2 DIVERSION

- A. Construct and maintain temporary diversion and protective works necessary for diversion and care of the stream and Hemphill Canal during construction, including, but not limited to, cofferdams, bladder dams, sheet pile cutoff walls, channels, flumes, pipes, drains, sumps, and others.
- B. For the purpose of stream diversion, the CONTRACTOR will be permitted to use any method approved by the COR and Engineer.

3.3 CLEANUP

- A. Remove or level temporary diversion and protective works in a manner approved by the COR.
 - 1. Removed materials remain property of the CONTRACTOR.
 - 2. Removed materials shall be hauled off-site for disposal, unless expressly agreed upon by the COR.
 - 3. Remove from stream channel, or level to give a slightly appearance and so as not to interfere with operation or usefulness of the dam or degrade fish habitat.
 - 4. Disposal of removed material is the sole responsibility of the CONTRACTOR and shall be completed in a timely fashion prior to Project closeout and in accordance with all federal, state, tribal and local laws and regulations.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement for Diversion of Stream and Hemphill Canal shall be made as a percent complete This bid item is considered 50% complete when Auburn Ravine has been diverted around the work area and Hemphill Canal is receiving flow as prescribed by OWNER and 100% complete when all controls have been removed and the area of work is returned to the natural process.

4.2 PAYMENT

- A. Payments shall be based on percent complete applied against the contract lump sum price. The lump sum contract price for Diversion of Stream shall include full compensation for all labor, materials, tools, equipment, and incidentals for doing all work necessary for the task as described in these specifications. A description of work is included at the head of this section. Any work associated herewith and not included in this or other bid items shall be deemed as included in the contract price for Diversion of Stream.

If no dollar amount is shown, the cost shall be considered as included in the bid items required for dewatering.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

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 PLANT SITE ACCESS

- A. The CONTRACTOR shall develop any necessary access to the Site, including access barriers to prohibit entry of unauthorized persons.
- B. **Utility Interference:** Where existing utilities interfere with the WORK, notify the utility owner and the ENGINEER before proceeding in accordance with the General Conditions.

3.2 CLEARING, GRUBBING, AND STRIPPING

- A. Construction areas shall be cleared of grass and weeds to at least a depth of 6-inches and cleared of structures, pavement, sidewalks, concrete or masonry debris, trees, logs, upturned stumps, loose boulders, and any other objectionable material of any kind which would interfere with the performance or completion of the WORK, create a hazard to safety, or impair the subsequent usefulness of the WORK, or obstruct its operation. Loose boulders within 10-feet of the top of cut lines shall be incorporated in landscaping or removed from the Site. Trees and other natural vegetation outside the actual lines of construction shall be protected from damage during construction.
- B. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove stumps, roots, buried logs, and other objectionable material. Septic tanks, drain fields, and connection lines and any other underground structures, debris or waste shall be removed if found on the Site. Objectionable material from the clearing and grubbing process shall be removed from the Site and wasted in approved safe locations.

- C. The entire clearing and grubbing area indicated on the drawings shall be stripped of vegetation. The stripped materials shall be stockpiled and incorporated into landscaped areas or other non-structural embankments as appropriate such as rocks for streambed, bank protection, or flow deflection purposes.
- D. Unless otherwise indicated, native trees larger than 3-inches in diameter at the base shall not be removed without the ENGINEER's approval. The removal of any trees, shrubs, fences, or other improvements outside of rights-of-way, if necessary for the CONTRACTOR's choice of means and methods, shall be arranged with the owner of the property, and shall be removed and replaced, as part of the WORK.

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.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement for Site Preparation shall be measured by prepared acre of area as identified on the Construction Drawings.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for Site Preparation as shown on the Construction Drawings, or as designated in Section 31 11 00 – Site Preparation. A description of work is included at the start of this section. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section.

- END OF SECTION -

SECTION 31 23 19 - DEWATERING

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall dewater trench and structure excavations, in accordance with the Contract Documents. The CONTRACTOR shall secure all necessary permits to complete the requirements of this Section of the Specifications.

1.2 CONTRACTOR SUBMITTALS

- A. Prior to commencement of excavation, the CONTRACTOR shall submit a detailed plan and operation schedule for dewatering of excavations in conformance with the requirements of General Conditions Section 9 – Submittals. The CONTRACTOR may be required to demonstrate the system proposed and to verify that adequate equipment, personnel, and materials are provided to dewater the excavations at all locations and times. The CONTRACTOR's dewatering plan is subject to review by the ENGINEER and OWNER.

1.3 QUALITY CONTROL

- A. It shall be the sole responsibility of the CONTRACTOR to control the rate and effect of the dewatering in such a manner as to avoid all objectionable settlement and subsidence.
- B. All dewatering operations shall be adequate to assure the integrity of the finished project and shall be the responsibility of the CONTRACTOR.
- C. 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.
- G. Flotation shall be prevented by the CONTRACTOR by maintaining a positive and continuous removal of water. The CONTRACTOR shall be fully responsible and liable for all damages which may result from failure to adequately keep excavations dewatered.
- H. If well points or wells are used, they shall be adequately spaced to provide the necessary dewatering and shall be sandpacked and/or other means used to prevent pumping of fine sands or silts from the subsurface. A continual check by the CONTRACTOR shall be maintained to ensure that the subsurface soil is not being removed by the dewatering operation.
- I. The CONTRACTOR shall dispose of water from the WORK in a suitable manner without damage to adjacent property. CONTRACTOR shall be responsible for obtaining any permits that may be necessary to dispose of water. No water shall be drained into work built or under construction without prior consent of the ENGINEER. Water shall be filtered using an approved method to remove sand and fine-sized soil particles before disposal into any drainage system.
- J. The release of groundwater to its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill and prevent flotation or movement of structures, pipelines, and sewers.

- K. Dewatering of trenches and other excavations shall be considered as incidental to the construction of the WORK and all costs thereof shall be included in the various contract prices in the Bid Forms, unless a separate bid item has been established for dewatering.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement for Dewatering shall be made as a percent complete. This bid item is considered 50% complete when the area of work is dry and 100% complete when all controls have been removed and the area of work is returned to the natural process.

4.2 PAYMENT

- A. Payments shall be based on percent complete applied against the contract lump sum price. The lump sum contract price for Dewatering shall include full compensation for all labor, materials, tools, equipment, and incidentals for doing all work necessary for the dewatering task as described in these specifications. A description of work is included at the head of this section. Any work associated herewith and not included in this or other bid items shall be deemed as included in the contract price for dewatering.

If no dollar amount is shown, the cost shall be considered as included in the bid items required for dewatering.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

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 SUBMITTALS

- A. Submit Stormwater Pollution Prevention Plan (SWPPP) for acceptance in accordance with the provisions of General Conditions Section 9 - Submittals .
 - 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)

MCMILLEN JACOBS – 033122
NID – HEMPHILL DIVERSION STRUCTURE

EROSION AND SEDIMENT CONTROL
GENERAL
PAGE 31 35 00 - 1

PART 3 -- EXECUTION

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, Section 31 35 30 – Erosion Control Vegetative, 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, sand bags, 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.

PART 4 -- MEASUREMENT AND PAYMENT (NOT USED)

4.1 MEASUREMENT

- A. Measurement for Erosion and Sediment Control shall be made as a percent complete. This bid item is considered 50% complete when controls have been installed and 100% complete when all controls have been removed and the area of work is returned to the natural condition.

4.2 PAYMENT

- A. Payments shall be based on percent complete applied against the contract lump sum price. The lump sum contract price for Dewatering shall include full compensation for all labor, materials, tools, equipment, and incidentals for doing all work necessary for the erosion and sediment control task as described in these specifications. A description of work is included at the head of this section. Any work associated herewith and not included in this or other bid items shall be deemed as included in the contract price for dewatering.

- 4.3 If no dollar amount is shown, the cost shall be considered as included in the bid items required for dewatering.

- 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 General Conditions Section 9 - Submittals.
- B. **Product Data:** Manufacturer's catalog sheets on geotextile fabrics.

PART 2 -- PRODUCTS

2.1 FABRIC

- A. Fabric may be woven or non-woven, made from polypropylene, polyethylene, or polyamid, and shall contain sufficient UV inhibitors so that it will last for 2 years in outdoor exposure.
- B. Fabric shall have the following properties:

Parameter	Standard Method	Value
Grab tensile strength	ASTM D 4632	100 lb
Burst strength	ASTM D 3786	200 psi
Apparent opening size	ASTM D 4751	Between 200 and 70 sieve size

- C. Fabric Manufacturer, or equal

1. **Mirafi**

2.2 POSTS

- A. Posts shall be wood, at least 2 inches by 2 inches, at least 6 feet long.
- 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.
- 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.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 31 35 00 Erosion and Sediment Control General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 31 35 00 Erosion and Sediment Control General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

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 State of California State Water Resources Control Board requirements and best management practices.

1.2 CONTRACTOR SUBMITTALS

- A. Submittals shall be in accordance with General Conditions Section 9 - 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.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 31 35 00 Erosion and Sediment Control General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 31 35 00 Erosion and Sediment Control General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 31 35 30 - EROSION 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.

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 be equal parts by weight of fescue and perennial ryegrass or perennial ryegrass and barley.
 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 Fabric:** 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**
 2. **Synthetic Industries**

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 9-inch long, 2-legged staples 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 3:1 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 9-inch penetration zone of the anchorage staples. Further, no stapling shall be undertaken while any frost exists within the staple 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.

3.7 MAINTENANCE AFTER FINAL ACCEPTANCE

- A. The CONTRACTOR shall water the permanently planted areas sufficiently to maintain the plant materials in a healthy condition during the 1 year correction period.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Work performed under this section shall be measured as incidental to Section 31 35 00 Erosion and Sediment Control General. These items are required to complete the Work but shall not be measure separately unless otherwise specified in the Contract Documents.

4.2 PAYMENT

Payment shall be made in accordance with Section 31 35 00 Erosion and Sediment Control General.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

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 General Conditions Section 9 - 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. ½ TON:

Rock Size	Percentage Larger
2000 lb.	0 - 5
1000 lb.	50 - 100

500 lb.	95 - 100
---------	----------

- 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:

Durability Absorption Ratio	Acceptability
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, 3/4 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.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as the cubic yards (CY) of the various types of rip rap, all of which have been completely installed. Measurements shall be the volume of rip rap placed as indicated on the Construction Drawings for the thickness specified.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the installation of Rip Rap as shown on the Construction Drawings, or as designated in Section 31 37 00 – Rip Rap. Payment for excavation of toe tranches and for all necessary excavation below natural ground or the bottom of excavated drainage channels will be included in the unit bid price for riprap. Payment for excavation required for shaping of slopes for riprap shall be included in the unit bid price for rip rap. Excavation grading and fill materials required to shape drainage channels shall not be included in the unit bid price for riprap. A description of work is included at the start of this section. Any work associated

herewith, but not included in other bid items, shall be deemed as included in the work described in this Section.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 31 62 13 - SHEET PILES

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide the sheet piles indicated or ordered by the ENGINEER to be left in place and which will become a part of the finished WORK. Sheet piling shall be in place in accordance with the Contract Documents.
- B. Temporary sheet piling installed by the CONTRACTOR to facilitate the installation or construction of other features of the WORK is not covered by this Section.
- C. Sheet piles shall be concrete sheet piles, steel sheet piles, or timber sheet piles, as indicated.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this Section:
 - 1. America Society for Testing and Materials (ASTM):
 - a. ASTM A 328 Specification for Steel Sheet Piling
 - b. ASTM A 690 Specification for High-Strength Low-Alloy Steel H-Piles and Sheet Piling for Use in Marine Environments

1.3 SUBSURFACE CONDITIONS

- A. A geotechnical engineering study has been performed for the Site. The soil report is available at the ENGINEER's office. The CONTRACTOR shall understand the recommendations and criteria in the report.
- B. The information in the geotechnical engineering report is available to the CONTRACTOR at its own risk, in the assessment of subsurface conditions at the Site.

1.4 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of General Conditions Section 9 - Submittals.
- B. The CONTRACTOR shall provide written notification to the ENGINEER of the scheduled date for installation of sheet piling at least one (1) week in advance of that date. The CONTRACTOR shall also describe the proposed method to install the sheet piling.

PART 2 -- PRODUCTS

2.1 STEEL SHEET PILES

- A. Steel sheet piles shall be rolled steel sections of the weight, shape, and length indicated. The material in steel sheet piles to be used in a marine environment shall meet the

requirements of ASTM A 690. Steel sheet piles not located in a marine environment shall meet the requirements of either ASTM A 328 or A 690.

- B. Splices in steel sheet piles shall be made by a full penetration butt weld of the entire cross section. Splices in the top 10-feet of the piles will not be permitted. Welding shall be performed by qualified welding operators.

PART 3 -- EXECUTION

3.1 DRIVING SHEET PILES

- A. Steel sheet piles shall be driven with vibratory hammers adequate to drive the piles to the required depths in satisfactory condition.
- B. To maintain satisfactory alignment, sheet piles shall be driven in increments of penetration necessary to prevent distortion, twisting out of position, or pulling apart at interlocks. To facilitate closure, it may be advantageous to set up piles for a complete length of wall before initial driving; piles thus setup can be progressively driven in short increments of penetration.

3.2 CUTOFFS

- A. Tops of sheet piling shall be cut off to a straight line at the elevation indicated or as directed. If a cutting torch is used on steel sheet piling, the cut surface shall be made as smooth as practicable by grinding or other approved methods.
- B. If heads of sheet piles are appreciably distorted or otherwise damaged below cut-off level, damaged portions shall be removed and replaced or repaired.
- C. Sheet piles damaged during driving, or driven out of proper position, or below cut-off elevation, shall be withdrawn and replaced with new piles.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as the linear foot of sheet pile, all of which have been completely installed including welded steel plate and half pipe. Measurements shall be made to the nearest linear foot.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the installation of Sheet Piles as shown on the Construction Drawings, or as designated in Section 31 62 13 – Sheet Piles. A description of work is included at the start of this section. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 33 11 10 - DUCTILE IRON PIPE (AWWA C151, MODIFIED)

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide ductile iron pipe and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCES

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

1. American Water Works Association (AWWA):

- a. AWWA C104 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
- b. AWWA C105 Polyethylene Encasement for Ductile-Iron Pipe Systems
- c. AWWA C110 Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in for Water
- d. AWWA C111 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
- e. AWWA C115 Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
- f. AWWA C116 Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.
- g. AWWA C150 Thickness Design of Ductile-Iron Pipe
- h. AWWA C151 Ductile-Iron Pipe, Centrifugally Cast for Water
- i. AWWA C153 Ductile-Iron Compact Fittings for Water Service
- j. AWWA C600 Installation of Ductile Iron Water Mains and Their Appurtenances
- k. AWWA C606 Grooved and Shouldered Joints

2. American Society for Testing and Materials (ASTM):

- a. ASTM C150 Portland Cement

1.3 CONTRACTOR SUBMITTALS

- A. Furnish Submittals in accordance with the requirements of General Conditions Section 9 - Submittals.
- B. Shop Drawings
 - 1. Certified dimensional drawings of valves, fittings, and appurtenances.
 - 2. For pipe 24-inches diameter and larger, line layout and marking diagrams which indicate the specific number of each fitting and the location and the direction of each fitting in the completed line. In addition, the line layouts shall include: the pipe station and invert elevation at changes in grade or horizontal alignment; elements of curves and bends, both in horizontal and vertical alignment; and the limits of each reach of restrained joints, or of concrete encasement.
- C. **Certifications:** Certified affidavit of compliance for pipe and other products or materials furnished under this Section and as specified in the referenced standards and the following supplemental requirements:
 - 1. physical and chemical properties; and,
 - 2. hydrostatic test reports.
- D. The CONTRACTOR shall be responsible for performing and paying for sampling and testing as necessary for the certifications.
- E. **Joint Design:** 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.

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 ductile iron pipe shall conform to AWWA C151, C104, and C105, subject to the supplemental requirements in this Section. The pipe shall be of the diameter and class indicated, shall be provided complete with rubber gaskets, specials, and fittings as required under the Contract Documents.
- B. **Markings:** The CONTRACTOR shall legibly mark specials 24-inches diameter and larger in accordance with the laying schedule and marking diagram. Each fitting shall be marked at each end with top field centerline.
- C. **Handling and Storage:** The pipe shall be handled as a minimum at the 1/3 points by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment that might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be supported on padded skids, sand or earth berms free of rock exceeding 3-inches diameter, sand bags, or suitable means so that the coating will not be damaged. The pipe shall not be rolled and shall be secured to prevent accidental rolling
- D. **Laying Lengths:** Nominal pipe laying lengths shall be 20-ft.
- E. **Finish:** The pipe shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.
- F. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing on the Drawings. The locations of correction pieces and closure assemblies are indicated. Any change in location or number of said items shall only be as accepted by the ENGINEER.

2.2 SPECIALS AND FITTINGS

- A. Fittings for ductile iron pipe shall conform to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi. Ductile iron fittings larger than 48-inches shall conform to AWWA C153.

2.3 DESIGN OF PIPE

- A. The pipe shall be designed, manufactured, tested, inspected, and marked according to AWWA C150 and C 151 except where modified by this Section.
- B. **Pipe Dimensions:** The pipe shall be of the diameter and class indicated.
- C. **Fitting Dimensions:** The fittings shall be of the diameter and class indicated.
- D. **Joint Design:** Ductile iron pipe and fittings 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.
- 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 FUSION BONDED EPOXY LINING

- A. **Fusion Bonded Epoxy 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 a fusion bonded epoxy lining applied in conformity with AWWA C116. 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.

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 a fusion bonded epoxy coating in accordance with AWWA C116

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 1-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 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.

PART 4 -- MEASUREMENT AND PAYMENT

- A. Work performed under this section shall be measured as the linear foot of the various diameters of pipe, all of which have been completely installed. Measurements shall be made to the nearest linear foot, measured along the centerline of the pipe and bends. Tees, wyes, and crosses shall be measured along their centerline as the size of the larger pipe involved.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the installation of Ductile Iron Pipe as shown on the Construction Drawings, or as designated in Section 33 11 10 – Ductile Iron Pipe (AWWA C151). A description of work is included at the start of this section. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

**SECTION 33 11 22 - LARGE PVC PRESSURE PIPE, RUBBER JOINTS
(AWWA C905, MODIFIED)**

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide polyvinyl chloride (PVC) pressure pipe, complete in place, in accordance with the Contract Documents.
- B. **Pipe Material Group No. 19.** The piping system defined in this section is referred to in the Pipe Schedule on Contract Sheet G-008 as Piping Material Group No. 19.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this Section:
 - 1. American Water Works Association (AWWA):
 - a. AWWA C104 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
 - b. AWWA C110 Ductile-Iron and Gray-Iron Fittings 3-in Through 48-in for Water and Other Liquids
 - c. AWWA C111 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
 - d. AWWA C600 Installation of Ductile-Iron Water Mains and Appurtenances
 - e. AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe 4-in Through 12-in for Water Distribution
 - f. AWWA C905 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14-in Through 48-in, for Water Transmission and Distribution
 - g. AWWA Manual M23 PVC Pipe - Design and Installation
 - 2. American Society for Testing and Materials (ASTM):
 - a. ASTM D2584 Test Method for Ignition Loss of Cured Reinforced Resins
 - 3. Plastic Pipe Institute (PPI):
 - a. PPI Technical Report TR 3/4 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 - Contractor Submittals.
- B. **Shop Drawings:** Drawings of pipe, fittings, and appurtenances. Calculations showing compliance with this Section. Manufacturer's literature on the metallic locating tape.
- C. **Certifications:** A certified affidavit of compliance for all pipe and other products or materials furnished under this Section.
 - 1. Hydrostatic proof test reports.
 - 2. Sustained pressure test reports.
 - 3. Burst strength 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. **Inspection:** Pipe shall be subject to inspection at the place of manufacture. 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.
- B. 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.
- C. **Tests:** Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with this Section and the referenced standards, as applicable.
- D. The CONTRACTOR shall perform said material tests. The ENGINEER shall have the right to witness testing; provided, that the CONTRACTOR'S schedule is not delayed for the convenience of the ENGINEER.
- E. In addition to those tests specifically required, the ENGINEER may request additional samples of any material for testing by the OWNER. The additional samples shall be furnished as part of the WORK.

PART 2 -- PRODUCTS GENERAL

- A. Large PVC pressure pipe (14-inch through 48-inch) shall conform to the applicable requirements of AWWA C905 and the additional requirements herein.

2.2 PIPE

- A. The pipe shall be of the diameter and pressure class indicated, shall be furnished complete with elastomeric gaskets, and specials and fittings shall be provided as required in the Contract Documents. The dimensions and pressure classes for large

PVC pressure pipe with Cast-Iron Pipe Equivalent O.D.'s shall conform to Table 2 of AWWA C905.

- B. **Additives and Fillers:** Unless otherwise provided in alternate qualification procedures of PPI-TR3, compounds which have a Hydrostatic Design Basis (HDB) of 4,000 psi at 73.4° F for water shall not contain additives and fillers that exceed the recommended values in Table 1, Part Y of PPI-TR3 (e.g., allowable content range for calcium carbonate is 0.0-5.0 parts per hundred parts of resin). If requested by the ENGINEER, the additive and filler content shall be determined by using the pyrolysis method per ASTM D 2584.
- C. **Joints:** Joints for buried PVC pipe shall be either an integral bell manufactured on the pipe or a separate coupling both employing an elastomeric gasket. The bell and coupling shall be the same thickness as the pipe barrel, or greater thickness. The sealing ring groove in the coupling shall be of the same design as the groove in cast iron fittings and valves available from local water works supply distributors. Where indicated, restrained joint pipe shall be ductile iron pipe. No restrained joint PVC pipe will be allowed.
- D. **Joint Deflection:** Deflection at the joint shall not exceed 1.5 degrees or the maximum deflection recommended by the manufacturer. No deflection of the joint shall be allowed for joints that are over-belled or not belled to the stop mark.

2.3 PIPE SCHEDULE

Table Error! No text of specified style in document.-1. PVC Pressure Pipe Schedule

Pipe Designation or Pipe Class	Nominal Diameter, inches	Maximum Sustained Pressure, P _w , psi	Cover Range, feet	Trench Condition Outside Diam+feet	Minimum Compaction, percent
100-5	36	100	10	5	90

2.4 FITTINGS

- A. Fittings shall be ductile iron conforming to AWWA C110, Class 250. PVC pipe fittings shall be mechanical joint.
- B. Each fitting shall be clearly labeled to identify its size and pressure class.

PART 3 -- EXECUTION

3.1 GENERAL

- A. Laying, jointing, and testing for defects and for leakage shall be performed in the presence of the ENGINEER, and shall be subject to approval before acceptance. Material having defects will be rejected and the CONTRACTOR shall promptly remove such defective materials from the Site.

- B. Installation shall conform to AWWA M23, instructions furnished by the pipe manufacturer, and to the supplementary requirements or modifications herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

3.2 HANDLING AND STORAGE

- A. **Handling:** Pipe, fittings, and accessories shall be carefully inspected before and after installation and those found defective shall be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, pipe, fittings, and accessories shall be cleaned, and shall be maintained in a clean condition. Proper facilities shall be provided for lowering sections of pipe into trenches. Under no circumstances shall pipe, fittings, or any other pipe-related material be dropped or dumped into trenches.
- B. **Storage:** Pipe should be stored, if possible, at the Site in unit packages provided by the manufacturer. Caution shall be exercised to avoid compression damage or deformation to bell ends of the pipe. Pipe shall be stored in such a way as to prevent sagging or bending and shall be protected from exposure to direct sunlight by covering with an opaque material while permitting adequate air circulation above and around the pipe. Store gaskets in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.3 TRENCHING AND BACKFILL

- A. Trench excavation and backfill shall conform to the requirements of Section 31 30 00 - Earthwork. The minimum backfill compaction in the pipe zone shall be 90 percent of maximum density per ASTM D 698.

3.4 INSTALLATION

- A. Bell-and-spigot pipe shall be laid with the bell end pointing in the direction of laying. Pipe shall be graded in straight lines, taking care to avoid the formation of any dips or low points. Pipe shall not be laid when the conditions of trench or weather are unsuitable. At the end of each day's work, open ends of pipe shall be closed temporarily with wood blocks or bulkheads.
- B. Pipe shall be supported at its proper elevation and grade, care being taken to secure firm and uniform support. Wood support blocking will not be permitted. The full length of each section of pipe and fittings shall rest solidly on the pipe bed, with recessed excavation to accommodate bells, joints and couplings. Anchors and supports shall be provided where indicated and where necessary for fastening work into place. Fittings shall be independently supported.
- C. Short lengths of pipe shall be used in and out of each rigid joint or rigid structure. Piping that does not allow sufficient space for proper installation of jointing material shall be replaced by one of proper dimensions. Blocking or wedging between bells and spigots will not be permitted.
- D. Joints shall be installed according to manufacturer's recommendations. Trenches shall be kept free of water until joints have been properly made. The maximum combined

deflection at any coupling shall be in accordance with the manufacturer's recommendations.

- E. Pipe shall be cut by means of saws, power driven abrasive wheels, or pipe cutters that will produce a square cut. No wedge-type roller cutters will be permitted. After cutting, the end of the pipe shall be beveled using a beveling tool, portable type sander, or abrasive disc.

3.5 INSTALLATION OF COPPER WIRE

- A. Polyvinyl chloride pipelines shall be provided with No. 10 AWG bare copper wire laid along the top of the pipe and held in place with ties or hitches of the same kind of wire spaced not more than 13-feet apart, or metallic locating tape laid along the centerline of the pipe trench at a depth of 18-inches below finish grade. In such case, the CONTRACTOR shall furnish manufacturer's literature completely describing the tape proposed. No tape shall be used prior to receipt of written approval of the ENGINEER.

3.6 SERVICE CONNECTIONS

- A. **Service Connections:** Direct tapping will not be permitted. Double strap bronze service clamps shall be used for all service connections. Service clamps shall have a bearing area of sufficient width along the axis of the pipe, so that the pipe will not be distorted when the saddle is made tight. An internal shell cutter shall be used to drill through the corporation stop to minimize PVC shavings, retain the coupon, and reduce stress. Single fluted shell cutters or twist drills are not acceptable. Lubricate the cutting and tapping edges of the tool with cutting lubricant. Make the cuts slowly and use the follower very lightly - do not force cutter through pipe wall. Shell cutter shall have sufficient throat depth to handle the heavy wall PVC pipe. Maximum outlet size permitted with service clamps or saddle is 2-inches.
- B. Tapping sleeves and valves shall be used for outlet sizes greater than 2-inches in diameter. Tapping sleeves shall be assembled and installed in accordance with the manufacturer's recommendations.

3.7 CONNECTIONS TO EXISTING PIPELINES

- A. The CONTRACTOR shall locate underground improvements and install the pipelines to the depths indicated. Where the new WORK is to be connected to existing pipelines, the CONTRACTOR shall make its arrangements with the serving utility well in advance of the connections, to allow adequate time for dewatering of the existing line, if necessary, and shall expedite the work to minimize water outages to the users. Where sections of existing distribution mains are taken permanently out of service and abandoned in place, the cut ends shall be plugged solid with concrete to a depth of not less than one pipe diameter.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Work performed under this section shall be measured as the linear foot of the various diameters of pipe, all of which have been completely installed. Measurements shall be

made to the nearest linear foot, measured along the centerline of the pipe and bends. Tees, wyes, and crosses shall be measured along their centerline as the size of the larger pipe involved.

4.2 PAYMENT

- A. The contract unit prices shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals for doing all the work necessary for the installation of PVC Pressure Pipe as shown on the Construction Drawings, or as designated in Section 33 11 22 – PVC Pressure Pipe (AWWA C905). A description of work is included at the start of this section. Any work associated herewith, but not included in other bid items, shall be deemed as included in the work described in this Section.

– END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 35 20 29 – INTAKE SCREENS

PART 1 -- GENERAL

1.1 SUMMARY

- A. The Intake Screen Supplier shall furnish all components, materials, sub-assemblies, and all appurtenant work for the intake screen, complete as defined in this specification, and in accordance with the requirements of the Contract Documents.
- B. Contractor shall perform all work required to install manufacturer-supplied Intake Screen including, but not limited to, excavation, concrete placement, hardware, and miscellaneous required components for a fully functional Intake Screen.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASTM A 36	Standard Specification for Carbon Structural Steel
ASTM A 276	Specifications for Stainless Steel Bars and Shapes
ASTM A 193	Stainless steel bolts
AWS D1.1	Structural Welding Code – Steel
AWS D1.6	Structural Welding Code – Stainless Steel
Agency Fish Screening Criteria (WDFW, NMFS, as applicable)	

1.3 WORK INCLUDED

- A. Contractor shall supply, install, and test Intake Screen as per the manufacturer directions.

1.4 DESCRIPTIONS

- A. This section covers the contract item Intake Screen, which includes the following:
 - 1. Furnishing, installing, and testing cone screen and drive assembly at the location shown.
 - 2. The intake screen shall include the following:
 - a. Cone shaped fish screen over the surface water supply pipeline entrance.
 - b. Lifting eyes to allow the screen to be lifted in and out of the water by owner-supplied lifting device.
 - c. A steel cover plate to fit over the pipe intake entrance, should the screen be removed from the intake.

- d. A self-cleaning system consisting of three (3) brush-cleaning arms that rotate around the screen and wipe the screen surface clean.
 - e. Electric motor unit drive mechanism integrated into the interior of the screen assembly to power the cleaning system and rotate brush assemble in both directions. Furnish power and signal cable of sufficient length to connect from control panel to electric motor inside screen assembly.
 - f. Remote control panel for cleaning system.
 - g. Testing.
 - h. Spare parts.
- B. The equipment furnished shall be fabricated, assembled, erected, and placed in proper operating conditions in conformity with approved detail drawings, specifications, engineering data, and recommendations of the equipment manufacturer.

1.5 SUPPLIER

- A. The Intake Screen and associated cleaning mechanism shall be designed and furnished by a single supplier with demonstrated experience with similar intake screening systems.

1.6 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.
- B. Product data, make, and model of manufactured components, including cone screen, physical dimensions and weights of components, hydraulic motor, coatings, and anchoring system.
- C. Shop drawings shall illustrate the general arrangement of the Intake Screen unit and system components including the drive unit, control panel, as well as dimensions, materials, connections and anchoring requirements.
- D. Construction materials used in the project, including product data sheets, material certifications for stainless steel.
- E. List of spare parts to be furnished.
- F. Three (3) sets of technical manuals detailing operation and maintenance information. The manuals shall include basic installation, removal, inspection, operating, and maintenance procedures.
- G. Welder certifications for stainless steel and carbon steel as appropriate.
- H. **Certificates:**
 - 1. Intake screen manufacturer's certification shall be submitted, attesting that the Intake Screen meets all applicable agency fish screening criteria.

1.7 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. **Delivery of Materials:** Intake Screen shall be delivered and placed without damage.

1.8 WARRANTY

- A. **All Components:** The Manufacturer shall furnish to the CONTRACTOR the Manufacturer standard 1-year workmanship warranty, commencing on the date of installation and acceptance at the Project by the OWNER, through the CONTRACTOR.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The cone screen unit shall be designed to cover the intake opening and prevent the entrainment and impingement of juvenile fish while allowing water to pass freely into the intake of the water supply pipeline. When the screen is installed it shall seal over the intake base.
- B. An internal flow cone baffle shall be incorporated to evenly distribute the intake flow over the screen area.
- C. The screen system shall use an electric motor driven brush cleaning system. The exterior of the screen shall be cleaned when the brush arms rotate about the top center of the screen unit and the brushes wipe the screen surface.

2.2 INTAKE SCREEN

- A. Design flow rate is 28.2 cubic feet per second with a design approach velocity of 0.33 feet per second.
- B. The screen shall be fabricated from wedgewire screen that has a maximum slot size of 1.75 mm.
- C. The screen shall have a support system welded to the back of the screen surface and designed for the site and intake conditions.
- D. The pipe entrance under the screen shall be fitted with a cover plate. The cover plate shall be placed over the entrance should the fish screen be removed from service.
- E. The screen shall seal against the level and smooth concrete base with a maximum gap of 1.75 mm.
- F. The minimum screen percent open area shall be 50 percent.
- G. Braided hose to protect the power and signal cable umbilical between the drive unit and owner supplied conduit.
- H. The screen shall be capable of being removed by owner supplied equipment using manufacturer supplied lifting lugs.

2.3 SCREEN CLEANING DRIVE UNIT

- A. Electric drive unit to be comprised of a submersible electric motor, gear reducer, and drive hub. All interfaces of dissimilar metals shall be electrically isolated and drive unit to be factory sealed for corrosion resistance. Submersible motor to be 240-VAC, 1-phase, 60 Hz and rated for 2.0 hp maximum. Drive unit shall be rated for continuous duty at 40-foot submergence, 15 minutes unsubmerged, and provided with moisture and temperature switches.
- B. CONTROL PANEL: Controls system for both automatic and manual screen cleaning operation and system monitoring.
 - 1. Control panel shall be furnished by the Manufacturer and include at least the following:
 - a. Input Power: 240 Volts, 1-phase, 60 Hz
 - b. Main circuit breaker with external disconnecting handle capable of being locked in the open position
 - c. Control transformer with line and load fuses
 - d. Surge arrestor
 - e. VFD for motor control
 - f. Fault light for system alarming
 - g. Enclosure: NEMA 4X rated enclosure that shall be free-standing or wall-mounted and fabricated from painted steel or stainless steel.
 - h. Constructed per UL508 standards and labeled as such.
 - 2. Cleaning Operation:
 - a. Cleaning Cycle: a screen cleaning cycle is defined as rotation of the brush assembly against the external wedgewire surface in a forward and then reverse direction. Both the cleaning cycle frequency and duration are operator adjustable to meet intake conditions.
 - 1) Frequency is defined as the number of cleaning cycles intervals per 24-hour period.
 - 2) Duration is the amount of time the brushes are in rotation in first a forward and then reverse direction.
 - 3) Factory programming will be set at a frequency of 3 cleaning cycles per day each with a duration of 60-seconds in a forward direction, a 3-second stop, and 60-seconds in the reverse direction.

3. Mode Selection – HAND/OFF/AUTO: Three-position maintained type switch for mode selection
 - a. HAND Mode – Manual Operation Mode
 - 1) Operator will command manual brush rotation via the FWD/REV two-position selector switch with spring-return to center type operator to engage rotation of the brush assembly in the designated forward or reverse direction.
 - b. OFF Mode – Non-operational Mode
 - c. AUTO Mode – Automatic Cleaning Mode:
 - 1) Timer will command automatic cleaning cycle when the cycle interval is reached.

2.4 CLEANING BRUSHES

- A. Brush material shall be 612 nylon.
- B. Brush arms shall be stainless steel and have stainless steel clips for supporting the brush.

2.5 PERFORMANCE STANDARDS

- A. The Intake Screen shall be sized so that the maximum approach velocity of the water at the screen to no more than 0.4 feet per second during a peak diversion at the lowest river elevation expected.

2.6 MATERIALS

- A. Materials shall conform to the following:
 1. Fish screen unit construction, except for the motors and drive plates, shall be fabricated from ASTM A 276, Type 304 Stainless Steel.
 2. All non-stainless steel shall conform to ASTM A 36 and epoxy coated after fabrication. Contractor may substitute ASTM A992 or ASTM A572 Grade 50 for ASTM A36. Dissimilar metal connections shall be insulated with gaskets as recommended by the screen manufacturer.
 3. Stainless steel bolting materials shall conform to ASTM A 193.

2.7 SPARE PARTS

- A. Spare parts shall be interchangeable with, and shall be made of the same material as, the corresponding part to be replaced. Provide the following spare parts:
 1. One (1) complete set of replacement brushes.

2.8 MANUFACTURERS

- A. **Intake Screens, Inc.**
- B. **Or approved equal**

PART 3 -- EXECUTION

3.1 FABRICATION AND WORKMANSHIP

- A. Metalwork shall be free from wrap, twists, dents, buckle and other defects. Installation shall be neat, plumb, square, straight and in alignment. Provisions shall be made for expansion throughout to avoid damage. Surfaces shall be cleaned and left free from stains, marks, burrs, or other defects.
- B. All stainless steel shall be pickled prior to shipping. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces.
- C. Welding on the fish screen unit shall be in accordance with AWS D1.1 and AWS D1.6 for stainless steel. Field welding and cutting operations shall be performed with tarps or shields to prevent slag or other debris from falling in the water.

3.2 QUALITY ASSURANCE

- A. Welding and welding operators shall be qualified in accordance with AWS D1.6 and D1.1 as appropriate. Procedure qualification tests shall be performed on samples of steel that matches the steel to be used in this section.

3.3 FIELD TESTING AND OPERATIONS AND MAINTENANCE MANUAL TESTING

- A. Manufacturer's representative to be present for an installation inspection, field test, and personnel training of the complete system for a total of two (2) consecutive 8-hour days on-site. Costs requiring the Manufacturer's representative to be on site any additional length of time for safety training or additional inspections, testing, and/or training due to improper installation or delays shall be borne by the Contractor.
 - 1. Installation Inspection: Manufacturer's representative shall issue a COPI upon inspection and acceptance of Contractor installed equipment.
 - 2. Field Test: Manufacturer's representative shall conduct operational field testing of equipment following issuance of COPI. Field test shall demonstrate proper operation and settings of all screen cleaning systems and control systems.
 - 3. Personnel Training: Manufacturer's representative shall conduct training of Owner's personnel following an operational Field Test. Training to include identification of major components, system operation, preventative maintenance recommendations, and troubleshooting.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 Measurement

- A. Measurement of Intake Screens will be made by the each.

4.2 Payment

- A. Payment for the accepted quantities will be made at the Contract unit price shown in the bid schedule and shall be full compensation for work prescribed in this Section and include training of Owner's personnel and functional testing.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 35 20 30 – AUTOMATIC UNDERSHOT CONTROL GATES

PART 1 -- GENERAL

1.1 SUMMARY

A. Section includes:

- 1 Requirements for designing, furnishing, installing, testing and training on the operation and maintenance of the Automatic Undershot Control Gate. Automatic Undershot Control Gate consists of the motorized Undershot gate, level sensors, batteries, automatic controller and an operator interface all within a suitable control enclosure.
- 2 The Control Enclosure shall be rated for outdoor service and protect against vandalism and environment typical of irrigation systems. It shall house the batteries, charging subsystem, internal control circuitry, the interface to the ultrasonic level sensors, a pre-programmed logic processor (RTU), and the operator interface. The enclosure shall include louvered vents and filters as necessary to withstand high ambient temperatures and wind borne dust.
- 3 Undershot gates shall be furnished complete with external (primary) frame, water tight seals, aluminum composite laminate gate panel assembly, wire rope and drum drive system with positive drive in both directions, self-locking worm reduction gearbox, 12-volt or 24-volt DC actuator with 256 count encoder and all required accessories for a complete field installation.
- 4 Manufacturer's representative shall provide on-site supervision during installation of the exterior frame and gate. Manufacturer's representative shall provide inspection, calibration, startup, functional testing, and training in the operation and maintenance of the Automatic Undershot Control Gate.

1.1 REFERENCE

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

A. Referenced Standards

- 1 American Bearing Manufacturer Association (ABMA).
- 2 American Gear Manufacturer Association (AGMA).
- 3 American Institute of Steel Construction (AISC).
- 4 American Society for Testing and Materials (ASTM)
 - a. A36, Standard Specification for Carbon Structural Steel.
 - b. A48, Standard Specification for Gray Iron Castings.
 - c. A108, Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality.
 - d. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

- e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - f. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - g. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - h. A240, Standard Specification for Heating-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
 - i. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 - j. A663, Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties.
 - k. B21, Standard Specification for Naval Brass Rod, Bar, and Shapes.
 - l. B98, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
 - m. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
 - n. D395, Standard Test Methods for Rubber Property-Compression Set.
 - o. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension.
 - p. D471, Standard Test Method for Rubber Property-Effect of Liquids.
 - q. D572, Standard Test Method for Rubber-Deterioration by Heat and Oxygen.
 - r. D2000, Standard Classification System for Rubber Products in Automotive Applications.
 - s. D2240, Standard Test Method for Rubber Property-Durometer Hardness.
 - t. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - u. F594, Standard Specification for Stainless Steel Nuts.
- 5 American Welding Society (AWS).
- 6 National Electrical Manufacturers= Association (NEMA).

B. Manufacturer's Qualifications

- 1 Provide proof of similar project installations that have operated successfully for a period of not less than 10 years. Provide project photos, Owner references, and project descriptions for at least 5 similar projects. Manufacturer's not able to provide acceptable quality assurance will not be allowed.
- 2 Manufacture of the Automatic Undershot Control Gate shall be carried out in accordance with an ISO 9001:2000 accredited Quality System.

1.2 CONTRACTOR SUBMITTALS

A. See Sections 9 - Submittals

- 1. Submit all items listed for Engineer's approval at least 21 days prior to gate fabrication.

B. Shop Drawings

1. Submit 2 sets of drawings that do not exceed 11"x 17" in size that clearly show at a minimum all connection details, gate dimensions, materials, elevations, and fasteners required for complete construction.

C. Design Calculations

1. Submit 2 sets of complete structural calculations on 8-1/2 " x 11" sheets. Calculations for gate and operators shall include at a minimum design loads and load diagrams, stress analysis, structural member sizing and all referenced standards.

D. Operation and Maintenance Manuals

1. Submit 2 sets of O&M Manuals.

E. Installation Guidelines

1. Submit 2 sets of manufacturer's complete installation guidelines.

F. Written Warranty

1. Provide a written warranty to the Owner, signed by both the manufacturer and the Contractor. The warranty shall state that the Automatic Undershot Control Gates shall be free of all manufacturers' defects for a time period of not less than 12 months from the date of gate calibration. All manufacturers' defects occurring during this time period shall be repaired at no additional cost to the Owner. Submit the warranty to the Owner 21 days prior to substantial completion.

G. Submit product data sheets and applicable test data for all materials.

PART 2 -- PRODUCTS

2.1 DESIGN PARAMETERS

- A. The Undershot gate leaf, frame system, and drive system shall be designed to withstand a water surface level with the top of the gate with the gate in the closed position. The manufacturer shall identify the intermediate position of the gate resulting in the greatest loading on the gate and base the design on this loading.
- B. The Undershot gates shall be designed to withstand an upstream water depth equal to the vertical height of the gate when the gate is in the fully closed position and a zero downstream water depth. (Applicable to 3 sided seal undershot gate only) Maximum deflection of the gate leaf and side panels shall be no greater than the requirements of AWWA C513-97.

- C. All gate panels shall be subjected to Finite Element Analysis using the ANSYS FEA system and the design life of the panels shall be 30 years. Design loads placed on the gate panel assembly shall not induce stresses in excess of those specified in AS1664 specification for structural aluminum. Wire ropes, rope drums, hinge pins and drive shafts shall all be designed to withstand design maximum loads with factors of safety conforming to applicable USA Standards

2.2 MATERIALS

- A. The Undershot gate shall be manufactured in accordance with manufacturing drawings. Key component materials shall be as follows: -

External (Primary) Frame:	Aluminum extrusion, grade 6351 T5
Gate Panels:	Skin Plates to be aluminum sheet, grade 5083 H321 or 5052. Extrusion to be Aluminum grade 6351 T5 and 6060 T581 (rope guides only).
Control Enclosure and Mast:	Aluminum extrusion, grade 6351 T5 or 6061 T6.
Wire ropes:	Stainless steel, grade 304, 7 x 19.
Worm gearbox output shaft:	Stainless steel, grade 431 or grade 316.
Gate Hinge Pins:	Stainless steel, grade SAF 2205.
Wire rope drums:	Acetyl co-polymer.
Seals:	EPDM, Duro Hardness 50.
Fasteners:	Stainless steel, grade 316.
Primary Frame Anchors:	Stainless steel, grade 316, Ultimate Tensile Strength 700 MPa, Yield Strength 450 MPa

2.3 GATE PANEL ASSEMBLY

- A. Gates shall be fully closed when gate leaf is fully lowered.
- B. The gate panel assembly shall consist of a gate leaf panel, interlocked together to form one composite panel assembly. The panels shall comprise two outer aluminum skin plates adhesively bonded to an internal core material. The structural perimeter members of the panels shall be extruded aluminum sections, adhesively bonded to both the internal core material and the outer skin plates. The thickness of the skin plates, the material type and thickness of the core, the size of the perimeter members and the type and thickness of the adhesive bond shall all be determined as a result of the design analysis carried out as described in 3.1 above.

- C. The gate panel assembly shall be housed in a proprietary Rubicon Systems extruded aluminum Internal Frame. The gate panel assembly shall be supported in the Internal Frame by grade SAF 2205 stainless steel fasteners and acetyl bushes.

2.4 SEALS

- A. The seals shall be extruded from EPDM, with rated hardness 50 Duro. The Seals shall be continuous and fitted to the internal frame of the Undershot gate, extending along the full perimeter of the outer and underside of the gate panel assembly. The seals shall be water tight per the requirements of AWWA C513-97.

2.5 EXTERNAL (PRIMARY) FRAME

- A. An extruded aluminum primary frame shall be anchored to the concrete structure of each regulating bay. The frame shall be anchored in accordance with manufacturer's installation instructions. The primary frame shall be the receptacle for the Undershot gate, which shall slide into the frame and lock into position in the frame. The primary frame shall be installed prior to filling the canal.

2.6 FASTENERS

- A. All anchor bolts, assembly bolts, screws, nuts, etc., shall be of ample size to safely withstand the forces created by operation of the gate under the specified head. Quantity, type, and size of fasteners shall be as recommended by the manufacturer. Anchor bolts shall be provided with two nuts each to facilitate installation. Fasteners shall be stainless steel, unless otherwise shown on the Drawings.

2.7 DRIVE

- A. The drive system shall be comprised of two 7 x 19, grade 304 stainless steel Wire ropes and acetyl rope drums. The rope through each rope drum shall be continuous and be fixed to the gate panel and top of lifting channels. Each rope shall be pre-tensioned during gate manufacture. The wire rope and drum mechanism shall be actuated by a 12 volt or 24-Volt DC electric motor, self-locking worm reduction gearbox and stainless steel drive shaft. The drive shaft shall be supported at both ends by an acetyl bearing block that is housed in the machined aluminum plates

2.8 GATE ACTUATION

- A. The gate motor, planetary gearbox, brake and encoder shall be coupled in a modular system and provided by a single manufacturer. The motor shall be a permanent magnet (electronically commutated) DC type.
- B. The 256 count digital incremental encoder shall be utilized to generate circuit pulses by which motor shaft rotation(s) can be detected and counted. Combined with the positive drive mechanism that moves the gate Undershot leaf both up and down, the encoder shall measure position of the gate to within ± 1.0 mm.

2.9 Power Supply

- A. The Automatic Undershot Control Gate with all components shall derive all power from the included sealed lead-acid batteries. Charging source shall be either solar or third party line power.
- B. Solar Option: The Automatic Undershot Control Gate shall be designed such that the power requirements of the actuator, communication device and all electronic components can be met with an 80 -140 watt solar panel (dependent on motor design). The solar panel shall carry warranties on power output as follows: 25-year warranty of 80% power output, 10-year warranty of 90% power output, and a 5-year limited warranty of materials and workmanship. The solar panel shall be mounted on a 15 feet mast that is fitted into and alongside the Control Enclosure. The mast shall be securely fastened to the Control Enclosure with hinge pins that when removed will allow the mast to pivot down for maintenance.

2.10 CONTROL ENCLOSURE

- A. The Control Enclosure shall be designed to mount directly on the gate or optionally on a concrete maintenance pad within 15 feet of the gate. The Control Enclosure shall include a lower “pedestal” to contain and protect the batteries, and an upper accessible controller housing. Access to the operator interface shall be via a lockable hinged cover plate. Both cover plate and controller housing shall be gasket sealed to the pedestal to prevent exposure to the weather. The pedestal portion of the Control Enclosure shall include a louvered vent with filter to allow heat dissipation and protection against wind borne dust. The electronics in the controller housing provides power and control of the gate and shall include the following components:
 - 1. Pre-programmed Remote Telemetry Unit (RTU): RTU shall be pre-programmed to provide the functionality described in paragraph 2.10 CONTROLS. The RTU shall support at minimum three interface ports. Port 1 to be used to maintain an internal communications network with the solar regulator, motor controller, power regulator board and motor encoder. Internal network to be Modbus RS-485. Port 2 is to be used for programming functions and shall support serial RS 232 connections with data speeds up to 57.6 kbps. Optionally, Port 2 shall be configurable to support connection to a data logger. Port 3 shall provide bi-directional communications to an internal or external data radio. Port Real-time data available over Port 2 and Port 3 include is listed in Attachment A.
 - 2. Batteries: Batteries shall have capacity to provide for normal automatic gate operations and communications for up to 5 days. In cyclic application the batteries shall be guaranteed to perform 400 x 100% charge and discharge cycles, at the end of which 60% of the batteries rated capacity is left. Note that the requirements of the Power Management functionality as noted below shall generally keep the battery within its float voltage range during the spring to autumn months of the irrigation season, and that the power management system shall feature a low-power hibernate mode for the winter months, such that the batteries will rarely be

subjected to deep discharge.

3. Power Management Subsystem: The gate shall be provided with a comprehensive power management subsystem. The technology of this subsystem shall provide solar regulation algorithms that have been developed in conjunction with the battery manufacturer's specifications. The battery charger feature shall utilize a temperature sensor to be fitted to the battery terminals to factor the battery temperature into the charging regime. The technology shall provide extensive solar regulation parameter monitoring, such that the health of the battery and solar panel can be accurately monitored over time. The Power Management subsystem shall also provide managed and alarmed load-shedding functionality to reduce the power consumption of the gate during periods of supply power outage. As the battery voltage drops below configurable thresholds, the motor drive circuitry shall be first disabled, followed by the radio/communications device, then the sensors to minimize power consumption. When power is restored, then the circuits are re-activated – sensors first, then radio/communications device, then motor. All of the system shut-down and turn-on voltage parameters shall be user configurable, with default values pre-selected based on manufacturer's system performance testing. The Power Management functionality shall be provided by the SolarDrive™ board developed by Rubicon.
4. Motor Control and Protection Subsystem: The gate shall be provided with motor controller functionality to ensure reliable gate movement and long motor life. The motor controller shall use MOSFET based solid state switching and not rely on electro-mechanical relays. The motor controller shall provide soft starting, real-time continuous current monitoring and over-current protection, and pulse-width-modulation frequency adjustment for torque monitoring and control. Motor control and protection functionality shall be provided by the SolarDrive™ board developed by Rubicon.
5. Operator Interface: Data shall be displayed and controls entered locally using a four line by twenty character LCD display and six-button tactile keypad which shall be integral to the controller housing and is protected by a lockable cover. All cabling and electrical connections for this display shall be integral to the controller housing with no field wiring or termination required. The display shall provide at minimum the following basic information. Additional system level, calibration and configuration data shall be available when performing maintenance:

Site Name	Communications Network ID
Instantaneous Flow Rate	Volume delivered since last reset
Upstream & Downstream Measured Level	Local/Remote Status & Selection
Control Mode Selection	Level & Flow Setpoints

Local Manual Control
(gate position)

Irrigation Emergency Stop

Full System Self-Test and
Diagnostic Information

6. ***[Optional - Radio, Cellular Modem, or Data Logger: include hardware specification and functional description if included with gate. Name manufacturer, model number] :***

2.11 CONTROLS

- A. Local Controls: The pre-programmed RTU shall provide both controls to both manually position the gate and automatically move it to achieve a desired (entered set point) upstream level or through flow. When placed in LOCAL MANUAL control mode, the gate will move to a position entered by the operator. When placed in LOCAL AUTO control mode, the operator can select either Upstream Level Control or Flow Control and enter the desired set point. When set in REMOTE control Mode, if a SCADA system is connected to the gate, the operator shall have all the same capabilities to control the gate from a remote location.
- B. Network Controls: Network Control is only available when used with other Rubicon gates and with the Rubicon NeuroFlo™ network control software. There are two automatic control modes available:
1. DEMAND Mode: The gate will automatically adjust to provide a through flow to match the actual demand in the network below the gate while maintaining a stable downstream water level.
 2. SUPPLY Mode: The gate will automatically adjust to provide a through flow to match the flow provided by the network above (upstream) of the gate while maintaining a stable upstream water level.

2.12 SENSORS

- A. Level Sensors: The ultrasonic level sensors shall be either housed in the gate internal frame which will act as stilling wells and protect sensor performance from debris, foam, silt and other contaminants, or external to gate. The sensors shall be easily accessible for removal and cleaning.

2.13 FLOW CALCULATION

- A. The Automatic Undershot Control Gate shall be supplied with flow measurement software that calculates instantaneous discharge and accumulated volumetric discharge. Standard submerged orifice flow calculation to be used.

2.14 SHOP ASSEMBLY

- A. Except for the external frame, the Undershot gates shall be completely assembled in

the shop to ensure that all parts fit and that the required dimensions and tolerances have been obtained. Assemble the gates in the normal position as shown on the Drawings.

2.15 SPARE PARTS

A. Provide the following spare parts for each size gate:

- 1 One set of drive motors.
- 2 One solar drive board.
- 3 One set of wire rope drum assembly.

2.16 MANUFACTURERS

- A. Rubicon Systems America
- B. No other systems will be acceptable.

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. After installation, the actuator and drive components be cleaned, lubricated and serviced in accordance with the manufacturer's instructions.
- B. Installation of both the external (primary) frame and the Undershot gate shall be carried out in a professional and workmanlike manner and in strict accordance with the installation procedures supplied by the manufacturer. Personnel engaged in the installation shall receive instruction by the manufacturer or its nominated representative, in the interpretation of the installation procedures prior to performing the installation.
- C. In addition to other times required in this and other Sections, a manufacturer's representative shall be on site at all times during installation of the Undershot gate and all its component parts including anchorages and frames.

3.2 FIELD TESTING

- A. Field testing shall be performed in the presence of the Engineer. Notify the Engineer of the proposed tests to be performed a minimum of 7 days before the tests are scheduled to begin.
- B. The gate manufacturer shall provide a representative for the field testing and inspection of the gates.

C. Alignment Test

- 1 Check gates and hoist alignment by operating gate from fully open to fully closed

position. The gate should travel with no apparent racking and/or binding.

- 2 Gate position shall be verified to be accurate to within ± 1 mm.
- 3 Water Level sensors shall be verified by bringing the gate position to the measured water elevation and visually inspected.

D. Gate Leakage Test

- 1 The Contractor shall provide all necessary equipment for the leakage test. Install temporary stoplogs, berm, or other approved method on the upstream side of the Undershot gate. Seal the stoplogs or berm, then fill the space between the stoplogs or berm and the gate with water to the top of the gate and maintain water level for 30 minutes.
- 2 The maximum allowable leakage rate for the gate shall be 0.1 gal/minute per foot of seating perimeter (per the requirements of AWWA C513-97)..

E. Manufacturer shall submit written documentation verifying all testing and that the Undershot gates are acceptable for complete operation.

3.3 TRAINING

A. Training shall adhere to requirements in *[example: Section 01630]*.

PART 4 -- MEASUREMENT AND PAYMENT

4.1 Measurement

A. Measurement of Automatic Undershot Control Gates will be made by the each.

4.2 Payment

A. Payment for the accepted quantities will be made at the Contract unit price shown in the bid schedule and shall be full compensation for work prescribed in this Section and include training of Owner's personnel and functional testing.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK