



TECHNICAL SPECIFICATIONS

Provo City Public Utilities

Airport Pump Station

100% SET

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City of Provo

Provo Airport Pump Station

Project Location:

3421 Mike Jense Parkway, Provo, UT 84601

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**CONTRACT DOCUMENTS and
TECHNICAL SPECIFICATIONS**

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APWA 2017 Standard Specifications as applicable

(not included herein)

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SECTION 01 00 50 ADMINISTRATIVE PROVISIONS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. This section includes reference standards, preconstruction conference, Contractor Submittals, Work sequence, Contractor use of premises, Owner-furnished services/products and field engineering.

1.2 RELATED SPECIFICATIONS

- A. Section 01 45 00 – Quality Control
- B. Section 01 57 00 – Construction Facilities and Temporary Controls

1.3 REFERENCE STANDARDS

- A. Obtain copies of standards when required by individual Specifications. Maintain copy at jobsite during progress of the specific work.
- B. Adhere to the following technical standards for construction. Where there is conflict between the different technical standards, follow in order of precedence as listed:
 - 1. As presented in the Contract Documents herein and Project Drawings.
 - 2. Provo City Standard Details, a Supplement to the Utah 2017 APWA Standards, found online.
 - 3. Utah 2017 APWA Standard Specifications (some of which are modified herein)

1.4 PRECONSTRUCTION CONFERENCE

- A. Before commencement of the Work, a preconstruction conference will be held at a mutually agreed time and place. Attendees will include:
 - 1. Contractor, its' superintendent and subcontractors as appropriate,
 - 2. Engineer and Resident Project Representative,
 - 3. Representatives of Owner,
 - 4. Representatives of affected utility companies as appropriate,
 - 5. Governmental representatives as appropriate, and
 - 6. Others as requested by the Contractor, Engineer or Owner.
- B. The purpose of the conference is to designate responsible personnel and establish a working relationship. Matters requiring coordination will be discussed and procedures for handling such matters established. The meeting agenda will be provided by the Engineer.

1.5 CONTRACTOR SUBMITTALS

- A. Procedures
 - 1. Transmit each Submittal to the Engineer with Contractor's standard Submittal form. Deliver Submittals electronically in .PDF format via email or hard copy to the Engineer as designated in the Preconstruction Conference.
 - 2. If Contractor elects to submit a paper copy of a Submittal or Shop Drawing, an electronic copy shall accompany it.



3. Allow 14 days for the Engineer to review and return Submittals. All Submittals will be returned in .PDF format via email.
- B. Identifying Information
 1. Identify Project, Contractor, subcontractor or supplier; pertinent drawing sheet and detail number(s), and Specification section number, as appropriate.
 - C. Product Data
 1. Mark product data to identify applicable products, models, options, and other data; supplement manufacturers' standard data to provide information unique to the Work. Submit only pages which are pertinent.
 - D. Manufacturer's Instructions and Certificates
 1. Submit manufacturer's printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, in quantities specified for product data.
 2. Provide certificates of compliance as requested by the Owner or as indicated in individual Specifications sections.
 - E. Samples
 1. Provide samples of materials as required by individual Specification sections and in the quantity indicated.
- 1.6 WORK SEQUENCE
- A. Notify the Owner at least 48 hours prior to commencing any Work.
 - B. Provide and coordinate construction schedule and operations with Owner.
 - C. Coordinate Work of the various sections of specifications to assure efficient and orderly sequence of installation of construction elements, with provisions for accommodating items installed later.
 - D. Coordinate with the Owner regarding construction schedule and progress such that the Owner may record survey data for new construction such as waterlines, valves, sewer lines, manholes, and appurtenances prior to permanently backfilling or concealing work.
- 1.7 CONTRACTOR USE OF PREMISES
- A. Coordinate use of premises with the Owner.
 - B. Owner, at their discretion, may occupy premises during entire period of construction for the conduct of their normal operations. Cooperate with Owner to minimize conflict and to facilitate the Owner's operations.
- 1.8 WORK BY OTHERS
- A. Not used.
- 1.9 OWNER FURNISHED SERVICES/PRODUCTS
- A. Not used.
- 1.10 FIELD ENGINEERING
- A. Provide field engineering services as required to establish grades, lines, and levels from construction stakes in order to complete the work in accordance with these drawings and specifications.



1.11 PERMITS

A. The following permits will be required for the project (this list may not be all-inclusive):

1. Building permit from Provo City.
2. SWPPP Permit from the Utah Department of Environmental Quality.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

END OF SECTION



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SECTION 01 45 00 QUALITY CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. This section includes general quality control, workmanship, manufacturer's instructions and certificates, and testing services.

1.2 RELATED WORK

- A. Section 01 00 50 Administrative Provisions

1.3 SUBMITTALS

- A. Before construction, identify testing agency including name, address, telephone number, licensed professional for testing agency who is to review services, names and levels of certification and years of experience of testing agency's laboratory and field technicians.
- B. During construction, submit all quality control test results to demonstrate that the work performed complies with the contract documents to Engineer within one week of each test.

1.4 QUALITY CONTROL - GENERAL

- A. Maintain quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce work of specified quality.
- B. Comply with industry standards for workmanship except when more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.
- C. Should manufacturers' instructions conflict with the Contract Documents, request clarification from Owner before proceeding.

1.5 TESTING LABORATORY SERVICES

- A. Services will be performed in accordance with requirements of local jurisdiction having authority and with specified standards.
- B. Reports will be submitted to Owner and Engineer giving observations and results of tests, indicating compliance or noncompliance with specified standards and with Contract Documents.

END OF SECTION



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SECTION 01 55 50 TRAFFIC CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Contractor's responsibilities to warn, guide and protect motorists and pedestrians affected by the construction zone.

1.2 RELATED WORK

1.3 REFERENCES

- A. AASHTO Roadside Design Guide, Current Edition
- B. American National Standards Institute (ANSI)
- C. Americans with Disabilities Act
- D. ATSSA: American Traffic Safety Services Association
- E. Quality Standards for Work Zone Traffic Control Devices
- F. International Safety Equipment Association (ISEA)
- G. Manual on Uniform Traffic Control Devices (MUTCD), Current Edition
- H. UDOT traffic control and safety requirements
- I. NCHRP – Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features

1.4 SUBMITTALS

- A. Contractor shall submit a Traffic Control Plan as necessary. The Traffic Control Plan must be signed and sealed by a professional engineer licensed in the state of Utah. The Traffic Control Plan must be accepted by the local authority / engineer prior to commencing work.
 - 1. Show how to provide the least amount of disruption to vehicular movement as construction work progresses.
 - 2. Show how to move pedestrians around or through the work site.
 - 3. Show how to handle signalized intersections.
 - 4. Show how to accommodate truck traffic that is high or extra wide (two lane width to pass truck) in a quick or immediate response time.
 - 5. Show placement, spacing and taper rates of traffic control devices.
- B. Submit copy of flagger or Traffic Control Technician certification when requested by Engineer.

1.5 SPECIAL TRAFFIC CONTROL REQUIREMENTS

- A. None.

1.6 TRAFFIC CONTROL TECHNICIAN

- A. Technician must be Engineer approved or ATSSA certified.
- B. Make at least four inspections of traffic control devices each day as follows:



- 1. Before beginning work shift.
 - 2. At mid-shift.
 - 3. Half an hour after the end of the shift.
 - 4. Once during the night.
- C. Submit inspection forms to the engineer at least weekly.
 - D. Remain available to correct work zone signing within 5 minutes of need or notification.
 - E. Coordinate traffic control with emergency services, transportation services, and local law enforcement.
 - F. Update the traffic control plan when requested.
 - G. Clean devices at least weekly.
 - H. Replace devices missing any part of the message or background.
 - I. Remove devices if they are no longer required.

1.7 FLAGGER

- A. Flagger must have a current Utah flagging certificate and must present proof of certification upon request by engineer.
- B. Equipment:
 - 1. 24" x 24" "Stop/Slow" sign.
 - 2. 6" to 8" long red wand for night flagging.
 - 3. Light plant for night flagging.
- C. Clothing:
 - 1. Clothed; full length pants and long or short sleeved shirt.
 - 2. Hard toed shoes
 - 3. Orange, red-orange hard hat and vest.
 - 4. Night clothing to be reflectorized.

PART 2 - PRODUCTS

2.1 PAVEMENT MARKINGS

- A. Refer to MUTCD requirements.

2.2 SIGNS, SIGNALING AND BARRICADES

- A. Refer to MUTCD requirements.
- B. Reflective Sheeting: ASTM D 4956.
- C. Use devices and systems that meet NCHRP-350 Report crash test requirements with the exception of arrow boards and portable variable message signs.

PART 3 - EXECUTION

3.1 TRAFFIC CONTROL PLAN

- A. Implement the Traffic Control Plan as approved.



- B. If changes to the Traffic Control Plan are desired submit a revised Traffic Control Plan to the engineer at least 10 working days prior to the requested changes.

END OF SECTION



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SECTION 01 57 00 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Requirements for controlling surface and subsurface environmental conditions at a construction site and related areas under the Contractor's responsibility. This includes temporary utilities, sanitary facilities, barriers and enclosures, surface water, erosion & sediment control, dust control, noise control, construction cleaning, groundwater control, pollution control, and removal of temporary facilities.

1.2 RELATED WORK

- A. Section 01 00 50 - Administrative Provisions

1.3 REFERENCES

- A. Utah DEQ Division of Air Quality rules.
- B. Utah DEQ Division of Water Quality rules.

1.4 SUBMITTALS

- A. Fugitive Dust Control Permit as required by Utah DEQ Division of Air Quality.
- B. Storm Water Permit as required by Utah DEQ Division of Water Quality.
- C. Layout of fences, barriers and enclosures.

1.5 TEMPORARY UTILITIES

- A. Set up and maintain in a neat and orderly manner temporary roads and paving, dewatering facilities, enclosures, identification signs and bulletin boards, waste disposal and temporary heat and lighting.

1.6 SANITARY FACILITIES

- A. Provide and maintain required facilities and enclosures. Existing restroom facilities shall not be used.

1.7 BARRIERS AND ENCLOSURES

- A. Provide barriers and enclosures as required to prevent public entry to construction areas while allowing for Owner's use of site, and to protect existing facilities and adjacent properties from damage from construction operations.
- B. Use local standards and codes for erection of adequate fences and barricades. Maintain all signing, barricades, fencing, drainage and other items as required to protect public and private property from damage caused by construction operations.

1.8 SURFACE WATER, EROSION AND SEDIMENT CONTROL

- A. Before work begins, obtain a Storm Water Permit as required by DEQ.
- B. Control surface water such that the construction area is not allowed to become wet from runoff from adjacent areas. Direct surface water away from these areas but not directed toward adjacent property, buildings, or any improvement that may be damaged by water. Do not allow surface water to enter sanitary sewers.



- C. Prevent erosion and sedimentation.
- D. Provide temporary measures such as berms, dikes, and drains.
- E. Do not start grading work until installation of all temporary control measures is complete.
- F. Complete installation and continue to maintain all erosion control in a timely manner.
- G. Do not pollute streams, canals, lakes and other water courses.
- H. Follow the more restrictive requirements when conflicts occur between erosion control specifications and federal, state, or local agencies laws, rules or regulations.
- I. Noxious weed free certification will be required for all straw, hay bales, fiver, mats, mulches, etc. used for erosion control.

1.9 DUST CONTROL

- A. Before work begins, obtain a Fugitive Dust Control Permit as required by DEQ.
- B. Provide suitable equipment to control dust or air pollution caused by construction operations to all work areas, storage areas, haul and access roads, or other areas affected by construction.
- C. All work shall be in compliance with the Federal, State, and local air pollution standards, and not cause a hazard or nuisance to personnel and the public in the vicinity of the work.
- D. Execute work by methods to minimize raising dust from construction operations.

1.10 NOISE CONTROL

- A. Use equipment that is equipped with noise attenuation devices. Comply with local laws and regulations.

1.11 CONSTRUCTION CLEANING

- A. All public and private areas used as haul roads shall be continuously maintained and cleaned of all construction caused debris such as mud, sand, gravel, soils, pavement fragments, sod, etc. Care shall be taken to prevent spillage on haul routes. Any such spillage shall be removed immediately and the area cleaned.
- B. Public roads shall be maintained in accordance with applicable ordinances and regulations.
- C. Throughout all phases of construction, including suspension of work, and until final acceptance of the project, the Contractor shall keep the work site clean and shall remove daily all refuse, dirt, damaged materials, unusable materials, and all other trash or debris that he has created from his construction activities.
- D. Materials and equipment shall be removed from the site as soon as they are no longer necessary; and upon completion of the work and before final inspection, the entire worksite shall be cleared of equipment, unused materials, and rubbish so as to present a satisfactory clean and neat appearance. All cleanup costs shall be included in the Contractor's Bid.

1.12 GROUND WATER CONTROL

- A. Provide a dewatering system sufficient to maintain excavations and foundations free of water as required in the Contract Documents.
- B. Remove all dewatering facilities when no longer required.
- C. Dispose of water in a manner that will not cause damage to adjacent or downstream areas or facilities.



1.13 POLLUTION CONTROL

- A. Soil: prevent contamination of soil from discharge of noxious substances (including engine oils, fuels, lubricants, etc.). Excavate and legally dispose of any such contaminated soil off-site, and replace with acceptable compacted fill and topsoil.
- B. Water: prevent disposal of wastes, effluent, chemicals, or other such substances adjacent to or into streams, waterways, sanitary sewers, storm drains or public waterways. Perform any emergency measures required to contain any spillage.

1.14 REMOVAL OF TEMPORARY FACILITIES

- A. Remove temporary materials, equipment, services, and construction prior to Substantial Completion inspection.
- B. Clean and repair damage caused by installation or use of temporary facilities. Remove underground installations to a depth of 2 feet; grade site as indicated. Restore existing facilities used during construction to specified, or to original, condition.

END OF SECTION



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**SECTION 11 31 00
OPEN SCREW PUMP EQUIPMENT**

PART 1 GENERAL

1.01 SUMMARY

A. The CONTRACTOR shall furnish, install and place in satisfactory operating condition open screw pump assemblies and appurtenances as shown on the Drawings and described in the Specifications.

B. Related Sections

- 1. General Conditions, Supplementary Conditions, and General Requirements sections apply to work of this Section.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC)
- B. American Society of Testing and Materials (ASTM)
- C. American Society of Civil Engineers (ASCE)
- D. American Welding Society (AWS)
- E. Steel Structures Painting Council (SSPC)

1.03 SYSTEM DESCRIPTION

A. Each screw pump shall be furnished complete with spiral steel flighted screw, upper and lower stub shafts, upper and lower support bearings, flow deflection plates, parallel-shaft gear reducer, flexible coupling, V-belts and sheaves, drive motor, automatic lower bearing lubrication system, and all necessary anchorage parts.

B. Design parameters for each unit:

1. Number of Pumps	2
2. Pump Capacity, gal/min	11,222
3. Lift, feet	21
4. Pump Diameter, inches	80
5. Number of Flights	3
6. Flight Thickness, inches	0.3125
7. Torque Tube Diameter, inches	36
8. Torque Tube Wall Thickness, inches	0.5
9. Maximum Rotational Speed, rev/min	31
10. Minimum Gear Reducer Torque Rating, inch-lb	294,184
11. Motor Size, hp	100



1.04 SUBMITTALS

- A. Unless named in the specifications, all equipment manufacturers who intend to bid on the Section 11310 equipment shall submit to the ENGINEER not less than fourteen (14) days prior to the bid date a complete pre-qualification package. The pre-qualification package shall include but not be limited to the following:
1. List of twenty (20) U.S. installations of similar type equipment comparable to the units specified.
 2. The term "installations" shall mean individual projects/contracts. Multiple equipment units for a project will be considered as one (1) installation toward meeting the experience requirements. Installations shall be only those in the United States (fifty states). The installation shall include, but not be limited to, the following:
 - a. Name and location of installation.
 - b. Name of person in direct responsible charge for the equipment.
 - c. Address and phone number of person in direct responsible charge.
 - d. Month and year the equipment was placed in operation.
 - e. Brief description of equipment.
 3. A complete set of drawings, specifications, catalog cut-sheets, and detailed descriptive material. This information shall identify all technical and performance requirements stipulated on the drawings and in the specification.
 4. Structural and mechanical screw pump computations. The computations shall clearly indicate the following design parameters:
 - a. Brake horsepower at the maximum capacity and lift.
 - b. Required reducer torque at the maximum capacity and lift.
 - c. Radial bearing load and thrust bearing load at the maximum capacity and lift.
 - d. Bearing center distance.
 - e. Maximum screw deflection at the maximum capacity and lift.

These design calculations shall be certified by the manufacturer and signed by a Professional Engineer.
 5. Detailed information shall be submitted for all items such as hardware, motors, reducers, and bearings.
 6. Vendor data shall be furnished to confirm the torque rating of the drive.
 7. List showing materials of construction of all components.
 8. Manufacturer's recommended spare parts.



9. Information on equipment field erection requirements including total weight of assembled components and weight of each sub-assembly.
10. A maintenance schedule showing the required maintenance, frequency of maintenance, lubricants and other items required at each regular preventative maintenance period, including all buy-out items.
11. Process equipment electrical requirements and schematic diagrams.
12. Complete list of deviations from the drawings and specifications.

1.05 QUALITY ASSURANCE

- A. In order to assure uniform quality, ease of maintenance and minimal parts storage, it is the intent of these Specifications that all equipment called for under this Section shall be supplied by a single manufacturer. The equipment manufacturer shall, in addition to the CONTRACTOR, assume the responsibility for proper installation and functioning of the equipment.
- B. The Contract Documents represent the minimum acceptable standards for the screw pump equipment for this project. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the drawings and specifications. If not named, equipment which is a "standard product" with that manufacturer shall be modified, redesigned from the standard mode, and shall be furnished with special features, accessories, materials of construction or finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of the specifications.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. The screw pump assemblies shall include all necessary equipment and appurtenances as manufactured by Lakeside Equipment Corporation of Bartlett, Illinois, or equal.

2.02 SPIRAL SCREW

- A. Spiral screw shall be fabricated of ASTM A36 steel. Each spiral screw shall have an outside diameter as noted in paragraph 1.03.B.4. with the number of flights as noted in paragraph 1.03.B.5. Flights shall be die formed and shall have a minimum thickness as noted in paragraph 1.03.B.6. Flights shall be helical shaped and continuously welded on both sides to the torque tube. There shall be no more than one flight butt weld per pitch, and all flight butt welds shall be full penetration joints.
- B. Each torque tube shall have a minimum diameter as noted in paragraph 1.03.B.7. with a minimum wall thickness as noted in paragraph 1.03.B.8. so that screw deflection shall not be greater than the bearing center distance divided by 2,000. Calculations for deflection and bearing loads shall be based on the dead weight of the screw plus the full weight of liquid being pumped. Decreased loading from buoyance effects shall not be considered in the design calculations.
- C. The torque tube shall be sealed water tight with a welded steel plate at each end. All surfaces of the end plates mating with the bolted stub shafts shall be finish machined while the pump is supported between centers in a lathe after welding to the support tube and after all flight welding is complete to assure alignment and parallelism.



- D. A solid steel upper drive shaft and lower stub shaft fitted with machine faced steel plate flange shall be fastened to the upper and lower ends of the fabricated spiral screw with ASTM A325 high-strength bolts.
- E. The screw shall be placed in a lathe and the flights shall be ground to a true radius.

2.03 LOWER BEARING ASSEMBLY

- A. The lower bearing assembly shall be a cam-type with a pressure grease lubricated bronze sleeve bearing pressed onto the shaft and shall carry the radial load of the screw. No thrust load shall be carried by the lower bearing.
- B. The bronze sleeve shall rotate with the lower stub shaft in a bearing housing containing a minimum of two (2) spring loaded lip seals at the top of the bearing assembly. The seals shall be arranged so that one seal excludes wastewater and contaminants from the bearing and the other holds the grease in the bearing. The use of less than two lip seals will not be acceptable.
- C. The bearing assembly shall permit precise angular (vertical) and lateral (horizontal) field adjustment to eliminate misalignment between the upper and lower bearings without the use of shims. Bearing assembly shall accommodate all static and operating deflections of the screw. Bearings with fixed or rigid shafts and housings shall not be acceptable.
- D. The bearing assembly shall be supplied with a split non-rotating shield installed between the housing and rotating screw for operation of the shaft and seals.
- E. The bearing assembly shall accommodate thermal expansion and contraction of the screw within the bearing housing on fully lubricated surfaces not subject to corrosion or seizure.
- F. The bottom of the bearing housing shall be fitted with an inspection plate that can be removed for inspection of the lower bearing without disassembly of the lower stub shaft or bearing housing.
- G. The use of roller or ball bearings will not be acceptable.
- H. There shall be a flow through grease system with grease entering the lower part of the housing and passing across the full face of the bearing sleeve to the upper seals, then to a grease collection container for confirmation the bottom bearing is receiving grease from the automatic lubrication system.

2.04 UPPER BEARING ASSEMBLY

- A. The upper stub shaft shall extend through a grease lubricated upper bearing assembly which shall consist of a split housing fitted with dual bearings, lower spring loaded lip seal, bearing spacer and upper spring loaded lip seal.
- B. All of the thrust load from the pump shall be carried by a spherical roller thrust-type bearing assembly and the upper screw pump radial load shall be carried by a spherical roller bearing. A single dual-purpose bearing will not be acceptable.
- C. The two bearings (radial and thrust) shall be positioned in the bearing housing so that the pressure center of the thrust bearing and radial bearing intersects the axis of the screw at the same point to provide true self-alignment in all planes.



- D. Both radial and thrust bearings shall be rated at a minimum of 100,000 hours AFBMA L10 theoretical design life, based on the dead weight of the screw plus the full weight of the liquid being pumped.
- E. Upper stub shaft shall be grooved and positively locked into the upper bearing assembly by a split collar and locking halter ring. Use of threaded nuts to lock bearings and shafts for support of thrust loading will not be acceptable.
- F. A split bearing housing shall be provided to allow removal of the cover for inspection of the bearings without removal of the stub shaft or the entire bearing assembly.

2.05 DRIVE ASSEMBLY

- A. The drive assembly shall be designed and constructed for a maximum screw rotational speed as noted in paragraph 1.03.B.9. The drive assembly shall consist of a parallel-shaft gear reducer, belts, sheaves, motor, and coupling.
- B. The gear reducer shall be a parallel-shaft, triple reduction, foot-mounted unit suitable for outdoor operation. Gear reducer sizing shall be based on the latest AGMA standards using a minimum 1.5 service factor based on the maximum torque requirements of the screw or a minimum 1.25 service factor based on motor horsepower, whichever is greater. The minimum gear reducer torque rating shall be as noted in paragraph 1.03.B.10.
- C. The gear reducer housing shall be manufactured from high quality cast iron accurately machined for perfect alignment of all shafts and gearing. The gear reducer housing shall be furnished complete with an air breather, drain plug, dipstick or oil level indicator, and an inspection cover. All casting joints shall be precision ground to ensure an oil-tight and dust-proof housing.
- D. The gearing shall be high quality allow steel, hobbed and ground for maximum accuracy. All shafts shall be supported by roller-type anti-friction bearings.
- E. The gearing and bearings shall be automatically splash or force feed lubricated. Force feed lubrication systems shall include a shaft-driven oil pump and all necessary piping integral mounted on the gear reducer. Oil cooling shall be accomplished by convection and shall not require an external cooling source.
- F. The low-speed and high-speed shafts shall be provided with spring loaded lip seals suitable for inclined mounting.
- G. A backstop shall be mounted on the high-speed shaft to prevent reverse rotation of the screw.

2.06 BELTS AND SHEAVES

- A. Power transmission from the motor to the reducer shall be by means of a set of V-belts and sheaves. Belts and sheaves shall be designed with a 1.5 service factor based on full motor horsepower.
- B. Sheaves shall be two section units for both drive and driven sheaves and shall consist of a tapered split shaft bushing with three tapped holes to which the sheave is attached by three cap screws. Changing sheaves shall not require a wheel puller.
- C. Belts and sheaves shall be covered with a fabricated steel belt guard in accordance with OSHA standards.



2.07 MOTOR

- A. Each unit shall be driven by an 1,800 rpm, 3 phase, 60 Hertz, 460 volt, horizontal, ball bearing, continuous duty, constant speed, Design B, normal starting torque, totally enclosed fan cooled foot-mounted motor with leads to gasketed conduit box for outdoor operation.
- B. Motor horsepower shall be as noted in paragraph 1.03.B.11.
- C. Motor shall be mounted on a fabricated steel plate which provides adjustment of belt slack.

2.08 FLEXIBLE COUPLING

- A. The upper stub shaft of the screw pump shall be connected to the drive assembly by a flexible coupling.
- B. Coupling shall be designed for a 1.5 service factor, based on brake horsepower and shall be keyed and bored to suit the reducer slow speed shaft and the screw pump upper stub shaft.
- C. The flexible coupling shall be covered with a removable guard in accordance with OSHA standards.

2.09 DEFLECTION PLATES

- A. A flow deflection plate shall be provided to curve around the upper section on the uptake side of the screw to deflect the liquid as the screw rotates.
- B. The flow deflection plate shall be fabricated of not less than $\frac{3}{16}$ -inch steel plate complete with stiffeners where required and galvanized steel anchors on 2-foot centers at the bottom edge.
- C. The deflection plate top edge shall have adjustable galvanized steel anchors at not more than 8-foot centers.

2.10 AUTOMATIC LUBRICATION SYSTEM

- A. Each screw pump shall be furnished with a positive pressure, automatic lubrication pump and $\frac{3}{8}$ -inch minimum diameter stainless steel grease line.
- B. The automatic lubrication pump shall provide grease lubricant to the lower bearing assembly with provisions at the pump to manually charge the grease line.
- C. Each lubrication pump shall be adjustable and shall provide 6 ounces per day at the minimum setting and 17 ounces per day at the maximum setting (nominal). Grease reservoir shall hold a minimum of 11 pounds of lubricant.
- D. The lubricant pump shall consist of an eccentric piston pumping element, a check valve and shall have a one-third ($\frac{1}{3}$) horsepower, TEFC, ball bearing, 460 volt, 60 Hz, 3 phase, gear motor connected to the lubricator by a flexible coupling.
- E. A centrifugal switch shall be furnished as an integral component of the grease pump and interlocked with the screw pump drive system. When the screw pump is required to operate, the lubrication pump motor shall switch on. As the lubrication pump motor reaches full speed, the centrifugal switch shall close, energizing the screw pump drive motor. If the grease pump motor stops the centrifugal switch shall open, de-energizing the screw pump drive motor. The centrifugal switch shall be rated for not less than 3 amps at 120 VAC, resistive.



- F. The lubrication system shall be factory assembled on a steel base plate. The coupling shall have a removable metal coupling guard in accordance with OSHA standards.
- G. Grease shall be recovered in a stainless steel collection container with two (2) ¼-inch holes located 1-inch from the top of the container to allow liquid to drain out of the container.

2.11 GROUTING MATERIALS

- A. Equipment manufacturer shall furnish a radius screed for the CONTRACTOR to place the finishing grout in the trough with the screw after the unit has been installed.
- B. Equipment manufacturer shall furnish to the CONTRACTOR one (1) set of grouting sheave(s) and belts to operate the screw at a reduced speed for grouting the trough with the screw pump drive.

2.12 ANCHOR BOLTS

- A. Equipment manufacturer shall furnish all anchor bolts of ample size and strength required to securely anchor each item of equipment. Anchor bolts, hex nuts, and washers shall be galvanized steel unless noted otherwise. Anchor bolts shall be J-type embedded, or L-type embedded. Expansion-type anchors will not be acceptable.
- B. Anchor bolts shall be set by the CONTRACTOR. Equipment shall be placed on the foundations, leveled, shimmed, bolted down, and grouted with a non-shrinking grout.

2.13 SHOP SURFACE PREPARATION AND PAINTING

- A. All fabricated carbon steel or cast iron components for submerged service shall be near-white blast cleaned per SSPC-SP10 and given a 2.5 to 3.5 mil dry film thickness coat of Tnemec Series 1 Omnithane Primer.
- B. All fabricated carbon steel or cast iron components for non-submerged service shall be commercial blast cleaned per SSPC-SP6 and given a 2.5 to 3.5 mil dry film thickness coat of Tnemec Series 1 Omnithane Primer.
- C. Electric motors, speed reducers, and other self-contained or enclosed components shall be supplied with the manufacturer's standard finish coating.
- D. Apply rust preventative compound to all machined, polished, and nonferrous surfaces which are not to be painted.

2.14 SOURCE QUALITY CONTROL

- A. All structural steel components shall be fabricated in the United States and shall conform to the requirements of the "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" published by the American Institute of Steel Construction. Except where specifically indicated otherwise, all plates and structural members shall have a minimum thickness of ¼-inch.
- B. The equipment manufacturer's shop welds and welding procedures shall be in accordance with the requirements of the latest edition of ANSI/AWS D1.1 "Structural Welding Code - Steel" published by the American Welding Society.

PART 3 - EXECUTION

3.01 FIELD PREPARATION AND PAINTING

- A. Finish painting and field preparation shall be performed as specified in Section .



- B. The CONTRACTOR shall touch-up all shipping damage to the paint as soon as the equipment arrives on the job site.
- C. Prior to the assembly all stainless steel bolts and nut threads shall be coated with a non-seizing compound by the CONTRACTOR.

3.02 INSTALLATION

- A. The manufacturer shall schedule three (3) trips to the project site for start-up assistance and inspection of installed equipment for proper operation as noted in Paragraphs 3.02.B and 3.04.A.
- B. After the CONTRACTOR has installed the equipment and the units are capable of being operated, the equipment manufacture shall furnish a qualified representative for a minimum of five (5) man days (up to 60 hours) to inspect the equipment and to supervise field testing and startup for the CONTRACTOR.

3.03 OPERATOR TRAINING

- A. Provide operator training for OWNER'S personnel after the system is operational. Training shall take place while manufacturer's representative is at the job site for equipment inspection.

END OF SECTION

**SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL**

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. General electrical requirements for equipment and services including, but not limited to:
 - 1. Shop finish.
 - 2. Rust-inhibiting compounds.
 - 3. Galvanizing.
 - 4. Fireproofing and fire ratings.

1.2 DESIGN REQUIREMENTS

- A. Service conditions: Provide equipment and material suitable for intended service and installation at location indicated.
- B. Low-voltage auxiliary and control power.
 - 1. Electrical power for ac control and instrumentation equipment:
 - a. Provide devices necessary for proper operation and protection of equipment during electrical power supply and ambient temperature fluctuations specified.
 - b. Design for continuous operation at any voltage from 85% to 110% of nominal voltage. Dropout voltage shall be 60% of nominal for relays and 75% for contactors and starters.
 - 2. Electrical power for dc devices:
 - a. Design for continuous operation on ungrounded station battery system, capable of maintaining operation at any voltage from 80% to 112% of nominal voltage.
 - b. Electrical devices served shall not impose ground connection on supply.
- C. Auxiliary power: Design auxiliary equipment for low voltage service, with electrical power designed to operate from one of nominal electrical power sources as follows and as indicated on Drawings:

Volts	Phase	Frequency
480Y/277	3	60
240/120	1	60

1.1 SUBMITTALS

- A. Product Data:
 - 1. List of proposed material identifying manufacturer, type and model number for equipment to be provided for complete job.
 - 2. Manufacturer's catalog sheets marked to indicate specific type, model or catalog number of equipment to be provided.
 - 3. Equipment drawings, elementary diagrams, schematics, wiring, performance curves, instruction manuals, and all other documentation necessary for complete description of material being supplied and as required to support installation, commissioning and maintenance of equipment. Manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted.
 - 4. List of recommended spare parts required for equipment start-up, commissioning and operation.
 - 5. List of special maintenance tools required for installation and operation of equipment. If necessary, provide additional data to clearly demonstrate that proposed alternate equipment meets or exceeds equipment as specified.

- B. Operation and maintenance manuals. Provide at minimum:
 - 1. Itemized equipment list.
 - 2. General description and technical data.
 - 3. Receiving, storage, installation, and testing instructions.
 - 4. Operating and maintenance procedures.
 - 5. Complete set of final drawings requiring no further action.
 - 6. Complete documentation of inspections and tests performed, including logs, curves, and certificates. Documentation shall note any replacement of equipment or components that failed during testing.
 - 7. Spare parts list.
 - 8. Lubrication recommendations.
 - 9. Warranty information.

1.2 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. Manufacturer of equipment specified shall be recognized in industry for normally supplying this type of equipment.
 - 2. Manufacturer shall be ISO certified.
- B. Installer qualifications:
 - 1. Installer shall be skilled in trade and shall have thorough knowledge of products and equipment specified.
 - 2. Cutting, drilling, trenching, or channeling necessary to properly install equipment shall be performed by competent skilled crafts people in safe, professional manner.
- C. Regulatory requirements: Perform electrical construction in accordance with NEC, local and state codes as applicable to job site.
- D. Materials and equipment furnished for permanent installation shall be new, unused, and undamaged.
- E. Asbestos not allowed.
- F. Parts shall be manufactured to American industry standard sizes and gages to facilitate maintenance and interchangeability. Metric sized components not allowed unless specifically requested and approved.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Pack, ship, handle, and store in accordance with manufacturer's requirements.
- B. Ship equipment completely factory assembled unless physical size, arrangement, configuration, or shipping and handling limitations make this impracticable. Shipping splits and required field assembly shall be identified with equipment submittals.
- C. Costs associated with sections, accessories, or appurtenances requiring field assembly shall be Contractor's responsibility.
- D. Separately packaged parts and accessories shall be consolidated and shipped together with equipment. Mark each container clearly to identify contents and as belonging with main equipment.
 - 1. Provide individual weatherproof itemized packing slips attached to outside of each container for contents included. Provide duplicate inside each container.
 - 2. Attach master packing list, covering accessory items for equipment, to main piece of equipment.
 - 3. Mark each container with project identification number for equipment and container

number followed by total number of containers.

- E. Equipment shall be suitably protected during shipment, handling, and storage. Damage incurred during shipment shall be repaired at not cost to Owner.
- F. Protect coated surfaces against impact, abrasion, and discoloration.
- G. Electrical equipment and insulation systems shall be protected against ingress of moisture. Use space heaters if necessary to protect against moisture.
- H. Exposed threads shall be greased and protected.
- I. Pipe, tube, and conduit connections shall be closed with rough usage plugs. Seal and tape open ends of piping, tubing, and conduit.
- J. Equipment openings shall have covers, and taped to seal equipment.
- K. Store materials in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer's instructions.

1.4 SCHEDULING

- A. Coordinate with Owner early and late shipping and delivery schedules for items requiring storage and handling at Site.

1.5 WARRANTY

- A. Electrical equipment shall be provided with manufacturer's standard warranty, but not less than 1 year.

1.6 MAINTENANCE

- A. Extra materials: Provide touchup paint in same type and color to repair at least 25% of finish-painted equipment surface. Paint shall be sufficient to perform touch-up painting in accordance with shop-applied material instructions for repair painting.
- B. Each piece of equipment shall be furnished with special tools as required for installation, maintenance, and dismantling of equipment.
 - 1. Furnish in quantities as necessary to complete work on schedule.
 - 2. Tools shall be new and shall become property of Owner.
 - 3. Tools and intended use shall be identified in assembly instructions. Tools shall only be used for their intended purpose.

PART 2 — PRODUCTS

2.1 FINISHES

- A. Manufacturer's standard coating systems shall be factory-applied. Coating systems shall provide resistance to corrosion caused by weather and industrial environments.
 - 1. Surfaces inaccessible after factory or field assembly shall be protected for life of equipment.
 - 2. Painted surfaces shall be filled to provide smooth, uniform base for painting.
 - 3. Surfaces requiring field welds shall not be coated within 3" (75 mm) of field weld.
- B. Coating material and application techniques shall conform to regulations of air quality management agency having jurisdiction.
- C. Exterior surfaces of control and electrical equipment, including panels, cabinets, switchgear, transformers, and motors shall be manufacturer's standard colors unless specified otherwise.
- D. Apply high-temperature coating systems to uninsulated equipment operating at temperatures at

or above 200°F.

2.2 RUST-INHIBITOR COMPOUNDS

- A. Uncoated machined and ferrous surfaces subject to corrosion shall be protected with rust-inhibitor compounds.
- B. Rust-inhibitor compounds used to protect surfaces of equipment and piping exposed to feedwater or steam shall be completely water-soluble.
- C. Surfaces to be field welded shall be coated with consumable rust-inhibitor compounds that will not affect quality of weld.
- D. External gasket surfaces, flange faces, couplings, rotating equipment shafts and bearings shall be thoroughly cleaned and coated with rust-inhibitor compounds.

2.3 GALVANIZING

- A. Galvanized structural steel members and steel assemblies shall be pickled after fabrication. Remove scale, rust, grease, and other impurities, then hot-dip galvanized in accordance with ASTM.
- B. If galvanized member is to be bolted, structural bolts shall be galvanized in accordance with ASTM.

2.4 HARDWARE

- A. Provide hardware including, but not limited to, anchor bolts, nuts, washers, expansion anchors, wire nuts needed for installation.
- B. Hardware smaller than 3/4" (19 mm) shall match NEMA standard size bolt holes on motors and electrical equipment.

PART 3 — EXECUTION

3.1 EXAMINATION OF SITE

- A. Contractor shall be responsible for familiarity with Project Site conditions. Equipment furnished and installed shall be capable of withstanding most severe conditions that will be encountered.

3.2 PROTECTION OF WORK

- A. Protect installed Work and provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.
- B. Damage occurring to building or equipment during installation shall be repaired or replaced to conditions existing prior to damage at no additional cost or delay to project or Owner.

3.3 INSTALLATION

- A. Install equipment and materials in accordance with manufacturer's recommendations and Drawings.
- B. Details for equipment and systems installed in accordance with industry standard techniques will not be furnished.
- C. Installation details furnished on Drawings shall be followed unless found to be unsafe, inappropriate for equipment specified, or unachievable due to site conditions.
- D. Install equipment indicated on Drawings as furnished by others, unless noted as installed by others, including but not limited to:
 - 1. Filtration Systems (including all control panels.)

2. Sodium hypochlorite generation, storage and dosing equipment.
 3. Chemical mixing and dosing equipment
- E. Except as otherwise specified or indicated on Drawings, equipment shall be installed plumb, square, and level.
- F. Sheet metal junction boxes, equipment enclosures, sheet metal raceways, and similar items mounted on earth-bearing walls shall be separated from wall not less than 1/4" (6 mm) by corrosion-resistant spacers.
- G. Equipment located outdoors shall be permanently sealed at base. Openings into equipment shall be screened or sealed as to prevent entrance of birds, rodents, and insects the size of wasps and mud daubers.
1. Sealing material at base shall be concrete grout.
 2. Small cracks and openings shall be sealed from inside with silicone sealant.
 3. Large openings shall use galvanized screen mesh.

3.4 FIRE PROOFING AND FIRE RATINGS

- A. Maintain fire-resistive integrity during construction.
- B. Penetrations through fire-resistive structures shall be sealed with fire-resistive material compatible with construction penetration.
- C. Where required by codes, local building officials, or fire marshal, furnish UL fire sealing systems and install in accordance with manufacturer's recommendations.

3.5 STARTUP AND TESTING

- A. Clean equipment interiors and exteriors prior to start-up and testing.
- B. Unless specified otherwise, tests performed shall be standard tests listed by ANSI/IEEE for intended equipment.
- C. Equipment shall be checked and placed in service ready for operation.
- D. Circuits shall be electrically tested after installation. Test power and motor circuits prior to final connection to equipment. Splices shall be complete prior to testing.
1. Provide equipment and labor required for testing.
 2. Circuit failing to test satisfactorily shall be replaced or repaired, and retested at no additional cost to Owner.
 3. Check power and motor circuits, dc power, and control circuits for:
 - a. Correct terminations.
 - b. Continuity.
 - c. Unintentional shorts and grounds.
 4. Check power conductors for correct phasing.
 5. Motor circuits shall be checked for proper rotation and motors "bumped" to verify correct machine rotation.
 6. Control, instrumentation, and thermocouple wire shall be checked for correct termination, continuity, freedom from shorts or grounds, and identification.
 7. Current transformer wiring shall be loop checked by injecting current at one end of loop and checking with clip-on ammeter at each field termination point to assure continuity and phase identification.
 8. Voltage transformer wiring shall be tested by applying voltage at one point and checking with voltmeter phase rotation meter and phase angle meter at each field termination point to assure continuity, identification and phase shift.

3.6 DEMONSTRATION

- A. Final start-up and check out shall be completed prior to Owner acceptance of project.

- B. Electrical installation shall be complete in every detail and capable of normal operation in presence of Owner or Owner's Representative to verify its readiness.

END OF SECTION

SECTION 26 05 05 ELECTRICAL EQUIPMENT

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section includes general electrical equipment used to complete the electrical system.

1.2 RELATED SECTIONS

- A. Related work specified in other sections includes but is not limited to:

1. Section 01 33 00 - Submittal Procedures
2. Section 26 05 00 - Electrical General Requirements
3. Section 26 05 13 - Conductors and Cables
4. Section 26 05 33 - Conduit and Raceways
5. Section 26 05 34 - Electrical Boxes and Fittings

1.3 SUBMITTALS

- A. Submittals will be required for all electrical equipment and shall be made in accordance with Section 01 33 00, CONTRACTOR's Submittals.

PART 2 MATERIALS

2.1 FULL-VOLTAGE, NON-REVERSING MOTOR CONTROLLERS

A. GENERAL

1. Provide each motor with a suitable controller and devices that will function as specified for the respective motors and meeting NEMA ICS 2, the NEC, and UL.
2. Provide each motor controller with thermal overload protection in all ungrounded phases. Use protection consisting of thermal overload relays meeting NEMA ICS 2 which are sensitive to motor current and mounted within the motor controller, or a combination of thermal protectors embedded within the motor windings and controller-mounted overload relays, as indicated. Use overload protection devices of the inverse-time-limit type.
3. Provide controller-mounted overload relays of the manual-reset type with externally operated reset button when used without motor thermal protectors; when used in conjunction with thermal protectors, provide the automatic reset type. Select and install overload relay heaters after the actual nameplate full-load current rating of the motor has been determined.
4. Install and connect any required thermal protector monitoring relay provided by motor manufacturer in motor-control circuit and provide manual reset function. Fuse thermal-protector circuits according to the manufacturer's recommendations.
5. The Booster Pump controller shall be provided with two sets of thermal overload devices, rated for the full load current of the existing motors. The controller shall have a selection switch on the front selecting which thermal overload will be in service.

B. FULL VOLTAGE MAGNETIC STARTERS

1. Provide starters meeting NEMA ICA 2, Class A, with the rating and enclosure shown.
2. Supply individual control power transformers where indicated. The transformers shall have sufficient capacity to serve the connected load and limit voltage regulation to 10-percent during contact or pickup. Fuse one side of the secondary winding and ground the other side. Provide primary, current limiting

- fuses on all control power transformers.
3. Provide a panel type voltmeter, nominal 4-1/2 inch model with 3-phase, OFF four position selector switch.
 4. Provide a panel type ammeter, nominal 4-1/2 inch model with 3-phase, OFF four position selector switch, C.T.'s with proper ratio.
 5. For nonhazardous, indoor, dry locations, provide heavy-duty, indicating lights, selector switches, and stations. Utilize General Electric Type CR 104P, or equivalent by Square D, Cutler-Hammer, or other acceptable manufacturer. Acceptable manufacturer. The use of other manufacturer's names referenced to materials herein, shall indicate the quality of material to be provided.

2.2 MODULAR OVERLOAD RELAYS

- A. Where called for on the Plans, modular overload relays shall be provided with the motor starters. The modular overload relays shall be 3-pole solid state devices set by one plug-in heater and shall protect all 3 phase of the motor in ambient temperatures ranging from -20 degrees to +70 degrees C.
- B. The jam modules shall plug in the modular overload relays and shall provide for instantaneous trip of the overload relay should the current exceed a preset value at any time after the motor has accelerated. The modules shall be adjustable to any value between the 150 percent and 400 percent of the motor full-load current.
- C. The underload modules shall plug in the MOR and shall provide for overload relay trip whenever the current falls below a set value after the motor has accelerated. The modules shall be adjustable between 50 percent and 90 percent of the full load value of the motor full load current.

2.3 CONTROL PANELS

A. ENCLOSURES

1. Manufacturers:
 - a. Hammond Manufacturing
 - b. Hoffman
 - c. Rittal
 - d. Or approved equal.
2. This specification includes enclosures to house electrical controls, instruments, terminal blocks, etc. If not indicated otherwise they shall be NEMA 12 for indoor and NEMA 3R for outdoor installations.
3. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket.
4. Enclosures shall be from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin. They shall be as manufactured by Hoffman, Fischer & Porter, or equal.
5. Finish - Steel: Finish shall be white enamel interior, light grey enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Plans should be checked for special conditions.

B. PILOT DEVICES:

1. Manufacturers:
 - a. Allen-Bradley, Bulletin 800T, 30 mm
 - b. Cutler-Hammer
 - c. Square D, Type K, 30 mm - Class 9001
 - d. Or equal.
2. Indicating lights, pushbuttons and selector switches shall be miniature oiltight units.

Contact blocks in control circuits shall be NEMA ICS, B150, rated 5 amperes inductive at 120 volts AC. Contact blocks for signal circuits shall be rated 0.06 amperes at 30 volts AC or DC and shall be hermetically sealed and reed switches. Pilot lights for 120 volt AC circuits shall be LED type. Where group lamp test circuits are not specified, individual pilot light assemblies shall be "push-to-test" type. Pilot lights shall be capable of being changed from the front of the panel without special tools.

C. TERMINAL BLOCKS:

1. Manufacturers:
 - a. Entrelec (ABB) M4/6
 - b. Square D Co.,
 - c. Buchanan,
 - d. Allen-Bradley,
 - e. Or equal
2. Terminal blocks shall be of the size required for conductors therein and a minimum of 50 percent spares shall be provided in each terminal box.

D. FUSE BLOCKS:

1. Manufacturers:
 - a. Entrelec (ABB), M10/13.SF2
 - b. Or approved equal.
2. DIN rail mounted.
3. Terminals shall accommodate 22-10 AWG solid or stranded wires.
4. Provide terminals rated for 600 VAC/VDC and 15 amperes.
5. Device shall be UL listed.

E. CONTROL RELAYS:

1. Manufacturer:
 - a. Idec RH series.
 - b. Allen-Bradley
 - c. Or equal.
2. Control relays shall be general purpose "midget" relays, 10 ampere contact rating, with 1, 2, 3 or 4 Form C contacts as shown on the drawings.
3. Relay shall be provided with blade style terminals.
4. Provide LED indicator light with relay.
5. Provide a standard DIN rail mount relay socket.
6. Relay life expectancy shall be in excess of 500,000 operations at 120 VAC.
7. Device shall be UL listed.

F. PROGRAMMABLE LOGIC CONTROLLER

1. Manufacturer/Model
 - a. Allen-Bradley MicroLogix Series.
 - b. Or approved equal.
2. Power: 24 VDC
3. Provide appropriate Input/Output capability for the I/O list as indicated on the drawings.
4. Unit shall include ethernet, RS485 and programming communications ports.

G. 10-INCH OPERATOR TOUCHSCREEN:

1. Manufacturer/Model
 - a. Automation Direct/EA9-T10WCL
 - b. Beijer/X2 Pro 10
 - c. Or approved equal.
2. Description: Panel mounted ethernet color operator touchscreen.
3. Power Supply: 24 VDC (18 to 32 VDC)

4. Display:
 - a. Resolution: 1024 x 600 (min)
 - b. Backlight: LED
 - c. Backlight life time: 20,000 hours
 - d. Brightness: 500 cd/m²
5. Communications:
 - a. 10/100 Base T Ethernet port
 - b. One RS232 Serial port
 - c. One RS422/485 Serial port
6. Environmental:
 - a. Operating Temperature: -10-deg C to +60-deg C.
 - b. Storage Temperature: -20-deg C to +70-deg C.
 - c. Humidity: 5% - 85% non-condensing.

2.4 INSTRUMENTATION

A. PRESSURE TRANSMITTER

1. Manufacturer/Model:
 - a. Mercoid Series PBLT2
 - b. Or Approved equals.
2. An electronic gage pressure measurement device tailored to the installation as shown on the drawings and suitable for the planned application shall be installed. The system shall include a pressure transducer with integral diaphragm seal to be installed in the station discharge piping. The pressure transmitter shall operate on 24 VDC, and shall provide a 4-20 mA DC signal to the level controller.
3. Pressure Range: 0-20 PSI
4. Suitable for Class 1 Division 1 hazardous areas.
5. Unit shall have a stainless steel process connection, 316L stainless steel isolating diaphragm, and filled with silicone.

PART 3 INSTALLATION

- A. Installation shall be as per manufacturers specifications.

****END OF SECTION****

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART I — GENERAL

1.1 SECTION INCLUDES:

- A. Wire and cable markings.
- B. 600 Volt single-conductor cable.
- C. Multiple conductor, low-voltage cable.
- D. Fixture wire.
- E. Bare conductor.

1.2 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM B 3 Specification for Soft or Annealed Copper Wire
 - 2. ASTM D 1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
 - 3. ASTM D 1518 Test Method for Thermal Transmittance of Textile Materials
 - 4. ASTM D3005 Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
 - 5. ASTM D 5034 Breaking Force and Elongation of Textiles Fabrics (Grab Test)
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE 383 Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations
- C. National Electrical Contractors Association
 - 1. NECA 1 Standard Practices for Good Workmanship in Electrical Contracting
- D. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA WC 70 Non-Shielded Power Cable 2000 V or Less

1.3 SUBMITTALS

- A. Refer to Section 01 33 00, Submittal Procedures for submittal procedures.
- B. Submittal Requirements: Before installation of wire and cable, submit the following information for each type and size of wire and cable:
 - 1. Manufacturer of wire and cable, and certificate of compliance;
 - 2. Number and size of strands composing each conductor;
 - 3. Average overall diameter of finished wire and cable;
 - 4. Minimum insulation resistance in megohms per 1000 feet at 30 degrees C ambient;
 - 5. Jacket composition and thickness in mils;
 - 6. Total number of conductors per cable;
 - 7. Shield material (if any) and thickness;
 - 8. Conductor resistance and reactance in ohms per 1000 feet at 25 degrees C ambient; and
 - 9. Conductor ampacity at 30 degrees C ambient for 600 V wire and cable.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
- B. Store wire and cable in secure and dry storage facility, in accordance with NECA 1.

PART 2 — PRODUCTS

2.1 WIRE AND CABLE MARKINGS

- A. Verify that wire and cable markings are in accordance with applicable NEMA and National Electrical Code requirements.

2.2 600 VOLT SINGLE CONDUCTOR CABLE

- A. Conductor Material: ICEA stranded or solid copper meeting requirements of ASTM B 3, soft drawn.
- B. Conductor Type:
 - 1. Size 12 AWG (4.0mm²) and Smaller: Solid conductor.
 - 2. Size 10 AWG and Larger: Class B stranded.
 - 3. Size 14 to 1/0 AWG: Type XHHW-2, cross-linked polyethylene insulated in accordance with NEMA WC 70.
 - 4. Size 2/0 AWG and Larger: Type XHHW-2, cross-linked polyethylene insulated in accordance with NEMA WC 70 or type RHH/RHW, ethylene-propylene-rubber-insulated in accordance with NEMA WC 70.
- C. Temperature Rating: Use cables temperature rated not less than 75 degrees C.
- D. Insulation Rating: 600 V.
- E. Provide conductor sizes No. 8 AWG and smaller in colors to match wire color-codes. Sizes No. 6 AWG and larger shall be color-coded with field-applied tape.

2.3 MULTICONDUCTOR, LOW-VOLTAGE POWER CABLES FOR MOTORS, FEEDERS, AND BRANCH CIRCUITS ROUTED IN CABLE TRAY, CONDUIT OR DUCT BANK:

- A. Voltage rating: 600-volt.
- B. Conductors: Annealed, bare copper, Class B, stranded, minimum size No. 12 AWG (4.0mm²).
- C. Insulation: Flame-retardant, cross-linked polyethylene (XLPE) or cross-linked polyolefin (XLPO), complying with physical and electrical requirements for NEC Type XHHW-2.
- D. Jacket: Flame-retardant, heat, moisture, and sunlight-resistant; cross-linked, low-smoke, nonhalogen polyolefin (XLPO).
- E. Phase conductors shall be cabled together with Class B stranded, uncoated copper grounding conductor and fillers. Ground wire size shall comply with requirements of UL 1277.
- F. Cover cable assembly with helically applied polyester binder tape with minimum 10% overlap.
- G. Marking: Insulated phase conductors shall be black and shall have printed numbers in accordance with ICEA Method 4. Each cable shall be identified by means of surface ink printing indicating manufacturer, number of conductors, size, metal, voltage rating, and UL listing as suitable for cable tray use.
- H. Cables shall pass IEEE 1202 70,000 Btu/hr, and ICEA T-29-520, 210,000 Btu/hr vertical tray flame tests, and individual conductors UL VW-1 vertical flame test.
- I. Conductors shall be temperature rated for 90°C maximum continuous operating temperature in wet or dry locations.

2.4 FIXTURE WIRE

- A. Provide fixture wire conforming to the following requirements:
 1. Type: SF-2 silicone rubber insulated.
 2. Conductor: Stranded copper conductor 16 AWG or larger as indicated.

2.5 BARE CONDUCTOR

- A. Use ASTM B 3, Class B stranded, annealed soft-drawn copper conductor unless otherwise indicated. Size as indicated. Use bare conductor for ground wire only.

2.6 INSTRUMENTATION

- A. Instrumentation cable shall have the number of twisted pairs indicated on the Plans and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 18 AWG minimum.
- B. The jacket shall be flame retardant Flamenal or Okoseal, 90 degrees C temperature rating. The cable shield shall be minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.
- C. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with Okoseal or Vulkene, 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.

2.7 COLOR CODING OF CONDUCTORS (600 V)

- A. Identify individual conductors of multi-conductor cables by means of solid colors, stripes, or printing, unless otherwise approved by the Resident Engineer.
 1. Jacket Printing: Use cables which have printing on the jacket or a printed marker tape under the jacket. Verify that jacket printing includes, but is not be limited to, the number of conductors, conductor size, voltage rating, name of manufacturer, manufacturer's type, and date of manufacture; and that this information appears at intervals of not more than 30 inches.
 2. Footage Marker Tape: Provide cables with a footage marker tape under the jacket or hot-foil footage printing on the jacket.
 3. Power Cables: Conform to the following color coding for power cables:

Conductor	480Y/277 V	240/120 V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	-
Neutral	White	White
Ground	Green	Green

- B. Use solid color insulation or solid color coating for branch circuit phase conductors 10 AWG and smaller and all neutral and equipment ground conductors.
- C. Use a background color other than white or green for phase conductors with colored tracers.
- D. For solid color coatings and tracers, use a strongly adherent paint or dye not injurious to the insulation which will not be obliterated by pulling into a conduit or raceway.
- E. On-site coloring of ends of conductor may be permitted by the Resident Engineer upon receipt of satisfactory evidence that the Contractor is unable to order color-coded wire and cable as specified. Provide certification from the cable manufacturer that the paint or dye proposed for field application is noninjurious to the insulation.

2.8 CONNECTORS AND INSULATING TAPES

- A. Splice and Terminal Connectors:
 1. Provide termination fittings listed for use with the cable furnished, NEMA standard.

2. For termination and splice fittings on No. 10 and smaller conductors use compression type or insulated, expanding-spring type. Make wire splices either self-insulating or provided with an insulating cap or heat-shrink insulating sleeve.
3. For termination and splice fittings on No. 8 and larger conductors use tool-applied compression connectors of material and design compatible with the conductors for which they are used.
4. For terminal connectors on conductors size No. 4/0 and larger use long-barrel, double-compression type, and furnish with two NEMA standard bolt holes in the tongue.

B. Insulating Material for Splices and Terminations:

1. Provide insulating material for splices and terminations of type accepted by the Resident Engineer for the particular use, location, and voltage.
2. For general use electrical insulating tape use vinyl plastic with rubber based pressure sensitive adhesive, which is pliable from temperatures of minus 18 degrees C to 105 degrees C. Verify the tape has the following minimum properties when tested in accordance with ASTM D 3005:
 - a. Thickness: 7 mils.
 - b. Breaking Strength: 15 pounds per inch.
 - c. Elongation: 200 percent.
 - d. Dielectric Strength: 10 kV/mil.
 - e. Insulation Resistance (Direct method of electrolytic corrosion): 10 MW.
3. For rubber electrical insulating tape for protective overwrapping use silicone rubber with a silicone pressure-sensitive adhesive. Verify the tape has the following minimum properties when tested in accordance with ASTM D1000:
 - a. Elongation: 525 percent.
 - b. Dielectric Strength: 13 kV.
 - c. Insulation Resistance (Indirect Method of Electrolytic Corrosion): 10 MW.
4. For Arcproof tape use flexible, conformable organic fabric, coated one side with a flame-retardant flexible elastomer, self-extinguishing, with the following minimum properties:
 - a. Thickness, ASTM D 1000: 55 mils.
 - b. Tensile Strength, ASTM D 5034: 50 pounds per inch.
 - c. Thermal Conductivity, ASTM D 1518: 0.0478 Btu (h/ft²/F).
 - d. Electrical Arc Resistance: Withstand 200 A arc for 40 seconds.
5. Mark each tape package to indicate shelf-life expiration date.

2.9 TERMINALS

- A. Conductors No. 10 AWG and smaller: Marathon 1500 Series.
- B. Conductors larger than No. 4/0 AWG: Terminate to finned copper bus bar drilled and tapped with standard NEMA sized and spaced holes.

2.10 CONDUCTOR BUNDLING STRAPS

- A. Provide conductor bundling straps formed from self-extinguishing nylon having a temperature range of -40 degrees F to 185 degrees F.
- B. Equip each strap with a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.
- C. Ensure all wire and cable ties installed outdoors and in exposed locations are made of ultraviolet-resistant material.

PART 3 — EXECUTION

3.1 INSTALLATION

- A. Furnish wires and cables to the site in unbroken standard coils or reels upon which a tag is attached bearing the manufacturer's name, trade name of the wire, and listing information.
- B. Complete wiring as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank

covers.

- C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the manufacturer.
- D. Bundle cable and conductors neatly and securely with nylon straps in branch circuit panelboards, cabinets, control boards, switchboards, and motor control centers. Bundle power cables separately from control cables.
- E. Install motor feeders, service connections, and extensions in accordance with the referenced codes. Install motor feeder in liquid-tight flexible conduit of 18 inches minimum length at motor conduit box.
- F. For wire pulling, comply with NECA 1 and the following:
 - 1. Install wire and cable in conduit as indicated. Do not use block and tackle or other mechanical means for pulling conductors smaller than 2 AWG in raceways.
 - 2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use lubricant and installation procedure as recommended by the cable manufacturer.
 - 3. Do not exceed the manufacturer's recommended pulling tension. For conduit runs with three bends, and cable sized larger than 2 AWG, provide cable tension measuring equipment and record the highest cable tension. Notify Resident Engineer 48 hours prior to such pulling operations and adjust schedule as necessary to permit observation.
 - 4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.
- G. Power and Control Cable Installation in Manholes and Pull boxes: Route cables along the manhole or handhole walls providing the longest possible slack. Form cables closely parallel to the walls. Prevent cable interference with duct entrances, and support cables on brackets and cable insulators, spaced at a maximum of 4 feet. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, the existing locations of cables, cable supports, and grounding shall be modified as required to provide a properly arranged and supported installation.
- H. Splices and Terminations:
 - 1. Use continuous lengths of wire and cable shall between power source and equipment. Where splices are required, make them only in approved fittings or junction boxes. Splices are subject to approval by the Resident Engineer. Follow manufacturer's instructions in splicing wire and cable.
 - 2. Splices allowed in lighting and general-purpose power circuits.
 - 3. Provide wire and cable connectors of high-conductivity, corrosion-resistant material with contact area equal to at least current carrying capacity of wire or cable.
 - 4. General lighting and general-purpose building power circuits:
 - a. Twist-type, insulated spring connectors for splices on solid or stranded conductors smaller than No. 6 AWG.
 - b. Use indent, hex screw, or bolt clamp-type connectors, with or without tongue for splices on solid or stranded conductors No. 6 AWG and larger.
 - c. Apply insulating 600-volt tape.
 - 5. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets.
 - 6. Use splice and terminator installation tools and installation techniques recommended by the manufacturer.
 - a. Mechanical hand tools, with dies for each conductor size as recommended by the manufacturer, may be used on conductor sizes through #6 AWG.
 - b. For conductor sizes larger than #6 AWG, use hydraulic tools with hexagonal or circumferential dies as recommended by the manufacturer.
 - c. Use compression tools which permanently imprint die information on the completed connection.
 - 7. Control Cables: Terminate each wire held with screw-type terminals using an insulated sleeve (nylon), ring-tongue-type or locking spade-type, crimp-on lugs.
- I. Termination of conductors to equipment with bolted connections:

1. Use compression type lugs:
 2. Compression lugs for cables 250 kcmil and larger shall have at least 2 clamping elements of compression indents, and provision for at least 2 bolts for joining to apparatus terminals.
 3. Crimping hand tools used for securing conductors in compression type connectors or terminal lugs shall be made for purpose and conductor sizes involved.
 4. Crimping tools shall be ratchet-type preventing tool from opening until crimp action is completed.
 5. Tools shall be product approved by connector manufacturer.
- J. Insulating tapes and compounds for terminations and splices shall be UL-listed for intended use, location, and voltage by manufacturer.
- K. Metal-clad cable, NEC Type MC, may not be substituted in place of cable and conduit unless specified otherwise, or unless approved in writing.

3.2 FIELD QUALITY CONTROL

- A. Inspect wire and cable for physical damage and proper connections.
- B. Perform continuity test on power and equipment branch circuit conductors.
- C. Verify phasing for circuits to three-phase loads.
- D. Test for insulation resistance in accordance with Section 26 08 00 Commissioning of Electrical Systems.
1. Test after splices and terminations are complete. Do not connect equipment to the cable system during tests.
 2. Acceptance Criteria for 600V wire and cable: 10,000,000 ohms
 3. Test Failure: In case insulation resistance values are unacceptable, correct deficiency and retest. If the test fails again, replace the entire wire or cable segment.

END OF SECTION

SECTION 26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 — GENERAL

1.1 SECTION INCLUDES:

- A. Grounding of Electrical Systems and Equipment.
 - 1. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.2 RELATED SECTIONS AND REFERENCES:

- A. Section 26 05 19 - Low Voltage Electrical Power Conductors and Cables.

1.3 SUBMITTALS

- A. Submit "Letter of Conformance" in accordance with Section 01 33 00 indicating specified items selected for use in Project with the following supporting data:
 - 1. Product Data: For the following:
 - a. Ground rods.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. Comply with UL 467.
- B. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.
- C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 — PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers:
 - 1. Grounding Conductors, Cables, Connectors, and Rods:
 - a. Chance/Hubbell (573-682-5521)
 - b. Copperweld Corp. (931-433-7177)
 - c. Thomas & Betts, Electrical (800-816-7809)
 - d. Approved equals.

2.2 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Section 26 05 19 - "Low-Voltage Electrical Power Conductors and Cables."
- B. Material: Aluminum, copper-clad aluminum, and copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.
- E. Grounding Electrode Conductors: Stranded cable.

- F. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.
- G. Bare Copper Conductors: Comply with the following:
 - 1. Solid Conductors: ASTM B3.
 - 2. Assembly of Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
- H. Copper Bonding Conductors: As follows:
 - 1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.
 - 2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
 - 3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- I. Ground Conductor and Conductor Protector for Wood Poles: As follows:
 - 1. No. 4 AWG minimum, soft-drawn copper conductor.
 - 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir, or cypress or cedar.
- J. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.
- K. Equipment Ground Conductor (Green) shall be included with all circuit conductors. In addition, provide a neutral conductor where applicable.

2.3 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.
- B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.
- C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: copper-clad steel. Size: 120" long by 3/4" in diameter.
- B. UFER: 25-feet of bare copper conductor installed in the footing or foundation wall. Connect copper to structural support steel.
- C. Metal Water Pipes: Where metal water piping is used, provide grounding electrode conductor to metal water piping. Use UL listed connection devices as required.

PART 3 — EXECUTION

3.1 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.
- D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

- E. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
 - 2. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
- B. Install equipment grounding conductors in all feeders and circuits.
- C. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.
- D. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
- E. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
- F. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 INSTALLATION

- A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
 - 1. Drive ground rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
 - 2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.
- B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
- D. Metal Water Service Pipe: If metal water pipe is installed, provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

- E. Water Meter Piping: If metal water piping is used, use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
- F. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

3.4 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Non-contact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A .
- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- B. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

3.6 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
 - a. Equipment Rated 500 kVA and Less: 10 ohms.
 - b. Manhole Grounds: 10 ohms.
4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Owner representative promptly and include recommendations to reduce ground resistance.

END OF SECTION

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SECTION 26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. Hangers and supports for electrical equipment and systems.
- B. Construction requirements for concrete bases.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.3 RELATED SECTIONS

- A. Section 26 05 33 - Raceway and Boxes for Electrical Installations.

1.4 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.5 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this project, with a minimum structural safety factor of five (5) times the applied force.

1.6 SUBMITTALS

- A. Submit under provisions of Section 01 33 00.
- B. Product Data: For the following:
 - 1. Steel slotted support systems.
- C. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include product data for components.
 - 2. Steel slotted channel systems. Include product data for components.
 - 3. Equipment supports.
- D. Welding certificates.

1.7 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.1.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07.

PART 2 — PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 4. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A36, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - (1) Hilti Inc.
 - (2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - (3) MKT Fastening, LLC.
 - (4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - (1) Cooper B-Line, Inc.; a division of Cooper Industries.

- (2) Empire Tool and Manufacturing Co., Inc.
 - (3) Hilti Inc.
 - (4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - (5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A325.
 6. Toggle Bolts: All-steel springhead type.
 7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 for steel shapes and plates.

PART 3 — EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT and RMC as required by NFPA 70. Minimum rod size shall be 1/4-inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with single-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 1. To Wood: Fasten with lag screws or through bolts.
 2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 3. To Existing Concrete: Expansion anchor fasteners.
 4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete four (4) inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than four (4) inches thick.

5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 30 10 Concrete Placement.
- C. Anchor equipment to concrete base.
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

SECTION 26 05 33 RACEWAY AND BOXES

PART 1 — GENERAL

1.1 SECTION INCLUDES:

- A. Conduit and Tubing:
 - 1. Rigid galvanized steel (RGS).
 - 2. PVS schedule 40 conduit (PVC).
 - 3. PVC coated rigid galvanized steel conduit.
 - 4. Flexible metal, liquid-tight conduit.

- B. Fittings:
 - 1. Rigid galvanized steel conduit.
 - 2. PVC conduit and tubing.
 - 3. PVC coated rigid galvanized steel conduit.
 - 4. Flexible metal, liquid-tight conduit.
 - 5. Flexible coupling, hazardous areas.
 - 6. Watertight entrance seal device.

- C. Outlet and Device Boxes:
 - 1. Cast metal.
 - 2. Case aluminum.
 - 3. PVC coated cast metal.
 - 4. Non-metallic.

- D. Junction and Pull Boxes:
 - 1. Outlet box uses as junction or pull box.
 - 2. Conduit bodies uses as junction boxes.
 - 3. Large sheet steel box.
 - 4. Large cast metal box, hazardous location
 - 5. Large stainless steel box
 - 6. Large steel box.
 - 7. Concrete box, non-traffic areas.
 - 8. Concrete box, traffic areas.

- E. Terminal Junction Box.

- F. Metal Wireways.

- G. Non-metallic wireways.

- H. Precast manholes and handholes.

- I. Conduit and tubing accessories.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges, Sixteenth Edition.
 - 2. ASTM International (ASTM):
 - a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
 - b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel

- c. Steel Plate, Sheet, and Strip.
- d. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
- e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
- f. D149, Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
- 3. Electronic Industry Alliance (EIA) and Telecommunications Industry Association (TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
- 4. National Electrical Contractor's Association, Inc. (NECA):
 - a. 101, Standard for Installing Steel Conduit (Rigid, IMC, EMT).
 - b. 102, Standard for Installing Aluminum Conduits.
 - c. 105, Recommended Practice for Installing Metal Cable Trays.
 - d. 111, Standard for Installing Nonmetallic Raceway (RNC, ENT, LFNC).
- 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. C80.1, Specification for Rigid Steel Conduit, Zinc Coated.
 - c. C80.3, Specification for Electrical Metallic Tubing, Zinc Coated.
 - d. C80.5, Specification for Rigid Aluminum Conduit.
 - e. C80.6, Intermediate Metal Conduit (IMC) - Zinc Coated.
 - f. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - g. TC 2, Electrical Polyvinyl Chloride (PVC) Plastic Tubing and Conduit.
 - h. TC 3, Polyvinyl-Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - i. TC 6, PVC Plastic Utilities Duct for Underground Installation.
 - j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
 - k. VE 1, Metallic Cable Tray Systems.
- 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
- 7. Underwriters Laboratories Inc. (UL):
 - a. 1, Standard for Flexible Metal Conduit.
 - b. 5, Standard for Surface Metal Raceways and Fittings
 - c. 6, Standard for Electrical Rigid Metal Conduit - Steel.
 - d. 6A, Standard for Electrical Rigid Metal Conduit - Aluminum, Bronze, and Stainless.
 - e. 50, Standard for Enclosures for Electrical Equipment.
 - f. 360, Standard for Liquid-Tight Flexible Steel Conduit.
 - g. 514B, Standard for Conduit, Tubing, and Cable Fittings.
 - h. 514C, Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
 - i. 651, Standard for Schedule 40 and 80 Rigid PVC Conduit.
 - j. 651A, Standard for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - k. 797, Standard for Electrical Metallic Tubing.
 - l. 870, Standard for Wireways, Auxiliary Gutters, and Associated Fittings.
 - m. 1242, Standard for Intermediate Metal Conduit.
 - n. 1660, Standard for Liquid-Tight Flexible Nonmetallic Conduit.
 - o. 1684, Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.3 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
 - a. Rigid galvanized steel conduit.
 - b. PVC Schedule 40 conduit.
 - c. PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer's warranty.
 - d. Flexible metal, liquid-tight conduit.
 - e. Conduit fittings.
 - f. Wireways.
 - g. Device boxes for use in hazardous areas.
 - h. Junction and pull boxes used at or below grade.
 - i. Large junction and pull boxes.
 - j. Terminal junction boxes.
2. Precast Manholes and Handholes:

- a. Dimensional drawings and descriptive literature.
 - b. Traffic loading calculations.
 - c. Accessory information.
 3. Equipment and machinery proposed for bending metal conduit.
 4. Method for bending PVC conduit less than 30 degrees.
- B. Informational Submittals: Manufacturer's certification of training for PVC-coated rigid steel conduit installer.

1.4 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
- B. PVC-Coated, Rigid Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 — PRODUCTS

2.1 CONDUIT AND TUBING

- A. Rigid Galvanized Steel Conduit (RGS):
1. Meet requirements of NEMA C80.1 and UL 6.
 2. Material: Hot-dip galvanized, with chromiated protective layer.
- B. PVC Schedule 40 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.
- C. PVC-Coated Rigid Galvanized Steel Conduit:
1. Meet requirements of NEMA RN 1.
 2. Material:
 - a. Meet requirements of NEMA C80.1 and UL 6.
 - b. Exterior Finish: PVC coating, 40 mils nominal thickness, bond to metal shall have tensile strength greater than PVC.
 - c. Interior finish: Urethane coating, 2 mils nominal thickness.
 3. Threads: Hot-dipped galvanized and factory coated with urethane.
 4. Bendable without damage to either interior or exterior coating.
- D. Flexible Metal, Liquid-Tight Conduit:
1. UL 360 listed for 105 degrees C insulated conductors.
 2. Material: Galvanized steel, with an extruded PVC jacket.
- E. Electrical Non-Metallic Tubing
1. UL listed for poured-in-place concrete.
 2. Manufacturer and Products:
 - a. Kraloy Kwikon Series
 - b. Approved equal

F. Electrical Metallic Tubing (EMT)

1. Material: Hot-dipped galvanized, high-grade steel with continuously welded seam.
2. External protective coating: Metallic zinc applied by hot-dip galvanizing or electro-galvanizing. Coating shall not flake or crack when conduit is bent.
3. Internal coating: Baked enamel or similar compound resulting in smooth surface.

2.2 FITTINGS

A. Rigid Galvanized Steel 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.
 - b. Manufacturers and Products:
 - (1) Appleton; Series BU-I.
 - (2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
 - a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
 - b. Manufacturers and Products:
 - (1) Appleton; Series GIB.
 - (2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
 - a. Material: Malleable iron with insulated throat with bonding screw.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - (1) Appleton, Series HUB-B.
 - (2) O-Z/Gedney; Series CH.
 - (3) Meyers; ST Series.
5. Conduit Bodies:
 - a. Sized as required by NFPA 70.
 - b. Manufacturers and Products (For Normal Conditions):
 - (1) Appleton; Form 35 threaded unilets.
 - (2) Crouse-Hinds; Form 7 or 8 threaded condulets.
 - (3) Killark; Series 0 electrolets.
 - (4) Thomas & Betts; Form 7 or 8.
 - c. Manufacturers (For Hazardous Locations):
 - (1) Appleton.
 - (2) Crouse-Hinds.
 - (3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
 - a. Concrete tight, hot-dip galvanized malleable iron.
 - b. Manufacturers and Products:
 - (1) Appleton; Series SCC Bolt-On Coupling or Series EC Three-Piece Union.
 - (2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting Manufacturers and Products:
 - a. Appleton; Type EYF, EYM, or ESU.
 - b. Crouse-Hinds; Type EYS or EZS.
 - c. Killark; Type EY or EYS.
9. Drain Seal Manufacturers and Products:
 - a. Appleton; Type SF.
 - b. Crouse-Hinds; Type EYD or EZD.
10. Drain/Breather Fitting Manufacturers and Products:
 - a. Appleton; Type ECDB.
 - b. Crouse-Hinds; ECD.
11. Expansion Fitting Manufacturers and Products:

- a. Deflection/Expansion Movement:
 - (1) Appleton; Type DF.
 - (2) Crouse-Hinds; Type XD.
 - b. Expansion Movement Only:
 - (1) Appleton; Type XJ.
 - (2) Crouse-Hinds; Type XJ.
 - (3) Thomas & Betts; XJG-TP.
 - 12. Cable Sealing Fittings:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
 - c. Manufacturers and Products:
 - (1) Appleton; CG-S.
 - (2) Crouse-Hinds; CGBS.
- B. PVC Conduit and Tubing:
- 1. Meet requirements of NEMA TC-3.
 - 2. Type: PVC, slip-on.
- C. PVC-Coated Rigid Galvanized Steel Conduit:
- 1. Meet requirements of UL 514B.
 - 2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
 - 3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
 - 4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
 - 5. Overlapping pressure-sealing sleeves.
 - 6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
 - 7. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
 - c. Pennacote.
 - 8. Expansion Fitting Manufacturer and Product: Ocal; OCAL-BLUE XJG.
- 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.
 - 3. Manufacturers and Products:
 - a. Thomas & Betts; Series 5331.
 - b. O-Z/Gedney; Series 4Q.
- E. Non-Metallic Tubing:
- 1. UL listed for cast-in-place concrete
 - 2. Kraloy Kwikon series
 - 3. Or approved equal.
- F. Electrical Metallic Tubing:
- 1. Fittings: Rust-resistant steel compression type.
 - 2. Connectors shall have insulated insert in throat.
 - 3. Die-cast aluminum material, and indent or set screw type, are not acceptable.
 - 4. Conduit bodies: Malleable iron for use with compression type fittings. Set screw type not acceptable.
- G. Watertight Entrance Seal Device:
- 1. New Construction:
 - a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.

- b. Manufacturer and Product: O-Z/Gedney; Type FSK or WSK, as required.
- 2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.3 OUTLET AND DEVICE BOXES

- A. Cast Metal:
 - 1. Box: Malleable iron or cast ferrous metal.
 - 2. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.
 - 3. Hubs: Threaded.
 - 4. Lugs: Cast Mounting. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS or FD.
 - b. Appleton; Type FS or FD.
 - 5. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA or EAJ.
 - b. Appleton; Type GR.
- B. Cast Aluminum:
 - 1. Material:
 - a. Box: Cast, copper-free aluminum.
 - b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
 - 2. Hubs: Threaded.
 - 3. Lugs: Cast mounting.
 - 4. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS-SA or FD-SA.
 - b. Appleton; Type FS or FD.
- C. PVC-Coated Cast Metal:
 - 1. Type: One-piece.
 - 2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
 - 3. Coating:
 - a. Exterior Surfaces: 40-mil PVC.
 - b. Interior Surfaces: 2-mil urethane.
 - 4. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
- D. Nonmetallic:
 - 1. Box: PVC.
 - 2. Cover: PVC, weatherproof, with stainless steel screws.
 - 3. Manufacturer and Product:
 - a. Carlon; Type FS or FD, with Type E98 or E96 covers.

2.4 JUNCTION AND PULL BOXES

- A. Outlet Box 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.
- C. Large Sheet Steel Box:
 - 1. NEMA 250, Type 1.
 - 2. Box: Code-gauge, galvanized steel.
 - 3. Cover: Full access, screw type.

4. Machine Screws: Corrosion-resistant.
- D. Large Cast Metal Box:
1. NEMA 250, Type 4.
 2. Box: Cast malleable iron, or ferrous metal, electrogalvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
 3. Cover: Hinged with clamps.
 4. Gasket: Neoprene.
 5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 6. Manufacturers and Products, Surface Mounted Nonhinged Type:
 - a. Crouse-Hinds; Series W.
 - b. O-Z/Gedney; Series Y.
 7. Manufacturer and Product, Surface Mounted, Hinged Type: O-Z/Gedney; Series YW.
 8. Manufacturers and Products, Recessed Type:
 - a. Crouse-Hinds; Type WJBF.
 - b. O-Z/Gedney; Series YR.
- E. Large Steel Box:
1. NEMA 250 Type 12.
 2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Engineer.
 3. Cover: Hinged with clamps.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
- F. Concrete Box, Nontraffic Areas:
1. Box: Reinforced, cast concrete with extension.
 2. Cover: Steel diamond plate with locking bolts.
 3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
 4. Size: 10 inches by 17 inches, minimum.
 5. Manufacturers and Products:
 - a. Utility Vault Co.; Series 36-1017.
 - b. Christy, Concrete Products, Inc.; N9.
 - c. Strongwell; "PG" Style.
- G. Concrete Box, Traffic Areas:
1. Box: Reinforced, cast concrete with extension and bottom slab.
 2. Cover: Steel checked plate; H/20 loading with screw down.
 3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
 4. Manufacturers and Products:
 - a. Christy, Concrete Products, Inc.; B1017BOX.
 - b. Utility Vault Co.; 3030 SB.

2.5 TERMINAL JUNCTION BOX

- A. Cover: Hinged, unless otherwise shown.
- B. Interior Finish: Paint with white enamel or lacquer.
- C. Terminal Blocks:
 1. Separate connection point for each conductor entering or leaving box.
 2. Spare Terminal Points: 25 percent, minimum.

2.6 METAL WIREWAYS

- A. Meet requirements of UL 870.

- B. Type: Steel-enclosed, lay-in type.
- C. Cover: Hinged with friction latch.
- D. Rating: Outdoor raintight.
- E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.
- F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.
- G. Knockouts: Without knockouts, unless otherwise indicated.
- H. Manufacturers:
 - 1. Circle AW.
 - 2. Hoffman.
 - 3. Square D.

2.7 NONMETALLIC WIREWAY

- A. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.
- B. Type: Fiberglass-enclosed, with removable cover.
- C. Captivated, corrosion resistant cover screws.
- D. Oil-resistant gaskets.
- E. Meet UL cold impact test to minus 35 degrees C.
- F. Manufacturer: Hoffman.

2.8 ACCESSORIES

- A. Identification Devices:
 - 1. Raceway Tags:
 - a. Material: Permanent, nylon or polyethylene.
 - b. Shape: Round.
 - c. Raceway Designation: Pressure stamped, embossed, or engraved.
 - d. Tags relying on adhesives or taped-on markers not permitted.
 - 2. Warning Tape:
 - a. Material: Polyethylene, 4-mil gauge with detectable strip.
 - b. Color: Red.
 - c. Width: Minimum 6 inches.
 - d. Designation: Warning on tape that electric circuit is located below tape.
 - e. Identifying Letters: Minimum 1-inch high permanent black lettering imprinted continuously over entire length.
 - f. Manufacturers and Products:
 - (1) Panduit; Type HTDU.
 - (2) Reef Industries; Terra Tape.
- B. Heat Shrinkable Tubing:
 - 1. Material: Heat-shrinkable, cross-linked polyolefin.
 - 2. Semi-flexible with meltable adhesive inner liner.
 - 3. Color: Black.
 - 4. Manufacturer: Raychem.

PART 3 — EXECUTION

3.1 GENERAL

- A. Conduit and Tubing sizes shown are based on the use of copper conductors.
- B. All installed Work shall comply with NECA Installation Standards.
- C. Crushed or deformed raceways not permitted.
- D. Maintain raceway entirely free of obstructions and moisture.
- E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- F. Aluminum Conduit: Do not install.
- G. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
- H. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- I. Group raceways installed in same area.
- J. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- K. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
- L. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- M. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- N. Install watertight fittings in outdoor, underground, or wet locations.
- O. 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.
- P. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- Q. Do not install raceways in concrete equipment pads, foundations, or beams.
- R. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- S. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- T. Install conduits for fiber optic cables, telephone cables, and data cables in strict conformance with the requirements of EIA/TIA 596-A.

3.2 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

- A. Minimum Cover: 2 inches, including all fittings.
- B. Conduit placement shall not require changes in reinforcing steel location or configuration.
- C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.
- D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns,

or beams unless approved by Engineer.

E. Slabs and Walls:

1. Trade size of conduit not to exceed one-fourth of the slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams:

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.3 CONDUIT APPLICATION

A. Diameter:

1. Interior: 3/4-inch Minimum.
2. Exterior: 1-inch Minimum.

B. Exterior, Exposed:

1. Rigid galvanized steel.
2. PVC-coated rigid galvanized steel.

C. Exterior Penetrations Through Concrete:

1. PVC-coated rigid galvanized steel.

D. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors:

1. Listed non-metallic tubing.
2. Rigid galvanized steel.

E. Direct Earth Burial:

1. PVC-coated rigid galvanized steel.
2. PVC conduit.

F. Under Slabs-On-Grade:

1. PVC-coated rigid galvanized steel.
2. PVC conduit

G. Corrosive Areas (Chlorine Room): PVC-Schedule 40 PVC.

3.4 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 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.

3. Wet or Corrosive Areas: Flexible, nonmetallic or flexible metal liquid-tight.
 4. Dry Areas: Flexible, metallic liquid-tight.
 5. Length: 18-inch minimum, 60-inch maximum, sufficient to allow movement or adjustment of equipment.
- B. Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.
 - C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.
 - D. Transition From Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.
 - E. Under Equipment Mounting Pads: PVC-coated rigid steel conduit.

3.5 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Apply heat shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- D. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.
- E. 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. 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.
 4. 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.

3.6 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze.
- C. Application/Type of Conduit Strap:
 1. Rigid Steel Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
 2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.

3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.
- D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
1. Wood: Wood screws.
 2. Hollow Masonry Units: Toggle bolts.
 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
 4. Steelwork: Machine screws.
 5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 6. 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.

3.7 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches, minimum.
- 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 Degrees 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.

3.8 EXPANSION/DEFLECTION FITTINGS

- A. Provide on all raceways at all structural expansion joints, and in long tangential runs.
- B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.
- C. Install in accordance with manufacturer's instructions.

3.9 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.

3.10 PVC-COATED RIGID STEEL CONDUIT

- A. Install in accordance with manufacturer's instructions.
- B. Tools and equipment used in the cutting, bending, threading and installation of PVC-coated rigid steel conduit shall be designed to limit damage to the PVC coating.
- C. Provide PVC boot to cover all exposed threading.

3.11 WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.
- C. Applications:
 - 1. Metal wireway in indoor dry locations.
 - 2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.12 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:
 - 1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
 - 2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.
- C. Sheet Metal Boxes, Cabinets, and Enclosures:
 - 1. General:
 - a. Install insulated bushing on ends of conduit where grounding is not required.
 - b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
 - c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
 - d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
 - e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
 - 2. Rigid Galvanized Conduit:
 - a. Provide one lock nut each on inside and outside of enclosure.
 - b. Install grounding bushing at source enclosure.
 - c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
 - 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, except where threaded hubs required above.
- 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.

3.13 UNDERGROUND RACEWAYS

- A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.
- B. Cover: Maintain minimum 2-foot cover above conduit unless otherwise shown.
- C. Make routing changes as necessary to avoid obstructions or conflicts.
- D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
- E. Union type fittings not permitted.
- F. Spacers:
 - 1. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench.
 - 2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
- G. Support conduit so as to prevent bending or displacement during backfilling.
- H. Installation with Other Piping Systems:
 - 1. Crossings: Maintain minimum 12-inch vertical separation.
 - 2. Parallel Runs: Maintain minimum 12-inch separation.
 - 3. Installation over valves or couplings not permitted.
- I. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.
- J. Provide deflectional/expansion fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.
- K. Backfill:
 - 1. As specified in Section 31 23 24, Trench Backfill. Controlled low strength fill is an acceptable bedding and pipe zone material and backfill material to within 12 inches of the surface.
 - 2. Do not backfill until inspected by Engineer.

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

3. Light Switch: Install on lock side of doors.
 4. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.
 5. Install cast/threaded boxes in exposed locations. Sheet steel boxes in concealed locations.
- D. Mounting Height:
1. General:
 - a. Dimensions given to centerline of box.
 - b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference. Do not straddle CMU block or other construction joints.
 2. Light Switch: 48 inches above floor.
 3. Thermostat: 54 inches above floor.
 4. Convenience Receptacle:
 - a. General Interior Areas: 36 inches above floor.
 - b. Outdoor, All Areas: 18 inches above finished grade.
 5. 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. Wood: Wood screws.
 2. Concrete or Brick: Bolts and expansion shields.
 3. Hollow Masonry Units: Toggle bolts.
 4. 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.

3.15 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 outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
- E. Use conduit bodies as junction and pull boxes where no splices are required and their use is allowed by applicable codes.
- F. Installed boxes shall be accessible.
- G. Do not install on finished surfaces.
- H. Install plumb and level.
- I. Support boxes independently of conduit by attachment to building structure or structural member.
- J. 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.
- K. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
- L. Boxes embedded in concrete or masonry need not be additionally supported.
- M. 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 Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
 - 4. Use boxes and covers suitable to support anticipated weights.
- N. 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.
- O. Mounting Hardware:
 - 1. Noncorrosive Dry Areas: Galvanized.
 - 2. Noncorrosive Wet Areas: Stainless steel.
 - 3. Corrosive Areas: Stainless steel.
 - 4. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.16 EMPTY RACEWAYS

- A. Provide permanent, removable cap over each end.
- B. Provide PVC plug with pull tab for underground raceways with end bells.
- C. Provide nylon pull cord.
- D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.
- E. Install flush with floor in finished traffic areas not adjacent to walls. Stub up a minimum of 6-inches above floor in non-traffic areas or adjacent to walls.

3.17 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination.
2. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
3. Provide nylon strap for attachment.

B. Warning Tape: Install approximately 18 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.

3.18 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain 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.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

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SECTION 26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. This Section includes specifications for providing nameplates, wire and cable markers, power circuit identification and conduit color coding.

1.2 RELATED SECTIONS

- A. Section 09 91 00 - Painting and Coating

1.3 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

- A. Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.
- B. Submit manufacturer's product data for mounting adhesive.
- C. Submit schedule for nameplates.

PART 2 — PRODUCTS

2.1 NAMEPLATES

- A. Engraved three-layer melamine laminated plastic, not less than 3/32-inch thick, black letters on a white background.
- B. Labels: Embossed adhesive tape, with 3/16-inch white letters on black background. Use only for identification of individual wall switches and receptacles, control device stations and similar.
- C. Laminated white-over-black plastic such that face is white with black letters, with 1/8" (3 mm) engraved letters securely fastened with minimum of 2 self-tapping, stainless steel screws.
- D. Motor starters, either separately mounted or contained in motor control centers, shall have nameplates identifying related equipment. Where separate control and indicating lights are used, starters shall have engraved or etched legends ("start", "stop", etc.) as shown on Drawings.
- E. Provide control stations with nameplates identifying related equipment. Control and indicating lights shall have engraved or etched legends as shown on Drawings.
- F. Circuit breakers within main switchboards and distribution switchboards shall be provided with nameplates identifying related equipment being served.
- G. Fused and nonfused switches shall have 2 front cover-mounted nameplates.
 - 1. Nameplate containing permanent record indicating switch type, manufacturer's name, catalog number, and appropriate rating for equipment served.
 - 2. Provide additional nameplate to identify associated equipment.
- H. Panelboards shall have front cover-mounted nameplates identifying panelboard, matching information shown on Drawings and associated panel schedule. Nameplate shall have at least 4 lines of text consisting of:
 - 1. Line 1: Panel equipment identification number.
 - 2. Line 2: IEEE Voltage Designation.

3. Line 3: Appropriate description from which power is derived, (i.e. fed from HP1 through XFMR-LP1).
 4. Line 4: Location of power source, (i.e. PP-1, NW wing).
- I. Lighting and auxiliary power transformers shall have front cover-mounted nameplates identifying transformer, matching information shown on Drawings. Nameplate shall have at least 2 lines of text that consist of:
1. Line 1: Transformer equipment identification number.
 2. Line 2: Location of derived power source (i.e. fed from MDB, Elec Rm Basement).
- J. Nameplates shall meet requirements of NFPA 70E

2.2 WIRE AND CABLE MARKERS:

- A. Non-fading, plastic, printed sleeve labels.
- B. Non-fading, plastic, printed cable tag with holes for attachment to cable with plastic cable ties.
- C. Mounting Screws: Stainless steel machine screws.
- D. Mounting Adhesive: Permanent.
- E. Legend:
 1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
 2. Control Circuits: Control wire number.

2.3 CONDUIT MARKERS:

- A. Conduits inside manholes, hand holes, building entrance pull boxes, and junction boxes shall be provided with 19-gage stainless steel identification tags, with 1/2" (13 mm) stamped letters and numbers.
 1. Attach conduit Identification tags with stainless steel banding. Tag position shall be readily visible for inspection.
 2. Tags shall provide, as minimum:
 - a. Circuit origination and destination.
 - b. Voltage.
 - c. Number of conductors in accordance with phase.
 - d. Number of phase conductors.
- B. Cables passing through or terminating in manholes, hand holes, and pull boxes shall have 19-gage stainless steel identification tags with stamped lettering that provides circuit identification information.
- C. Provide power, control, and instrumentation cables with permanent type identification markers with typed cable numbers and from/to information at each point of termination. Cable numbers and from/to information will be provided for circuits not associated with low-voltage panelboards.
 1. Position cable markers to be readily visible for inspection.
 2. Cable numbers shall match those as shown on Drawings.
 3. Provide wire tags at each termination point for each conductor. Tags shall be permanent, wrap around, heat-shrinkable type with typewritten information.

2.4 SELF-ADHESIVE LABELS

- A. Self-adhesive labels shall be 1/4" high with 1/8" high lettering.

PART 3 — EXECUTION

3.1 INSTALLATION

- A. Degrease and clean surfaces to receive nameplates.
- B. Install nameplates parallel to equipment lines.
- C. Secure nameplates to equipment fronts using screws or adhesive. Secure nameplate to inside face of recessed panelboard or cabinet doors in finished locations.

3.2 IDENTIFICATION SCHEDULE

- A. Conductors: Provide sleeve wire markers on each conductor in panelboard, gutters, pull boxes, manholes, and at load connection. In gutters, pull boxes, and manholes, if cables are not spliced, a cable tag may be used. Attach tag securely to cable with plastic cable tie.
 - 1. Power and Lighting Circuits: Identify with branch circuit or feeder number.
 - 2. Control Wiring: Identify with control wire number as indicated on the Contract Drawings.
- B. Provide nameplates of minimum letter height as scheduled below.
 - 1. Panelboards, Switchboards, Uninterruptible Power Supplies, Motor Control Centers, Lighting Controllers: 3/8 inch, identify equipment designation; 1/4 inch, identify voltage rating and source.
 - 2. Disconnect Switches: 3/8 inch, identify equipment designation; 1/4 inch, identify voltage rating, source, and load served.
 - 3. Individual Circuit Breakers in Panelboards: 1/4 inch; identify circuit.
 - 4. Motor Starters in Motor Control Centers: 1/4 inch; identify circuit and load served, including location.
 - 5. Individual Circuit Breakers, Enclosed Switches, and Motor Starters: 1/4 inch; identify load served.
 - 6. Transformers: 3/8 inch; identify equipment designation. 1/4 inch; identify primary and secondary voltages, primary source, and secondary load and location.
 - 7. Devices: 1/4 inch; identify device.
 - a. Control devices.
 - b. Pushbutton stations.
- C. Contractor shall provide a printed label on each electrical load (device outlet box, light switch, receptacle, instrument, device, etc) indicating the power source panelboard and circuit number. Label shall be black lettering on white background.

3.3 CONDUIT COLOR CODING

- A. Coordinate color of paint with Section 09 91 00, Painting, to identify conduit by system.
- B. Low-voltage Distribution System: Unpainted or black.

END OF SECTION

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SECTION 26 22 13
LOW-VOLTAGE GENERAL PURPOSE TRANSFORMERS

PART I — GENERAL

1.1 SECTION INCLUDES:

- A. Dry-Type two-winding transformers.

1.2 REFERENCES:

- A. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA ST 20 Dry Type Transformers for General Applications
 - 2. NEMA TP 1 Guide for Determining Energy Efficiency for Distribution Transformers

1.3 SUBMITTALS

- A. General: Refer to Section 01 33 00, Submittal Procedures, for submittal requirements and procedures.
- B. Product Data: Submit manufacturer's product data of manufactured materials and equipment including the following.
 - 1. Outline and support point dimensions of enclosures and accessories
 - 2. Unit weights
 - 3. Voltage, kVA and impedance ratings and characteristics
 - 4. Loss data, efficiency at 25, 50, 75 and 100 percent rated load
 - 5. Sound level
 - 6. Tap configuration
 - 7. Insulation system type and rated temperature rise.
- C. Operation and Maintenance Data: Submit in accordance with Section 01 78 23, Operation and Maintenance Data, including the requirements identified above for submittal information.
- D. Test Reports: Submit test reports of factory and field tests performed, verifying that performance of equipment meets specification requirements.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Ship each unit securely wrapped, packaged, and labeled for safe handling of shipment and to avoid damage or distortion.
- B. Store transformers in secure, warm and dry storage facility.
- C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 — PRODUCTS

2.1 DRY TYPE TWO-WINDING TRANSFORMERS

- A. Dry Type Transformers: NEMA ST 20 and TP 1; factory-assembled, air cooled dry type transformers; ratings as shown on Contract Drawings.
- B. Insulation system and average winding temperature rise for rated kVA as follows:

1. 1 to 15 kVA: Class 220 insulation, 115 degrees C rise.
 2. 16 to 500 kVA: Class 220 insulation, 115 degrees C rise.
 3. 501 to 2000 kVA: Class 220 insulation, 80 degrees C rise.
- C. Load Ratings and Transformer Cooling: Load ratings, unless noted otherwise, are assumed to be AA (air convection cooling). For transformers larger than 500 kVA, provide mounting hardware and internal thermostats appropriate for future installation of external fans. Provisions shall be capable of increasing the transformer full-load rating by 50 percent.
- D. Winding Taps
1. Transformers Less than 15 kVA: Two 5 percent, full-capacity taps below rated voltage on primary winding.
 2. Transformers 15 kVA and larger: NEMA ST 20.
- E. Sound Levels: NEMA ST 20
- F. Basic Impulse Level.
1. Low-voltage Dry-Type Transformers: 10 kV.
- G. Ground core and coil assembly to enclosure by means of a visible, flexible copper grounding strap.
- H. Mounting: Transformers 75 kVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 kVA shall be suitable for floor or trapeze mounting.
- I. Coil Conductors: Continuous windings with terminations brazed or welded.
- J. Enclosure: NEMA ST 20; Type 1, drip-proof.
- K. Isolate core and coil from enclosure using vibration-absorbing mounts.
- L. Nameplate: Include transformer connection data.

PART 3 — EXECUTION

3.1 INSTALLATION

- A. Set transformers plumb and level.
- B. Use flexible conduit, 2-foot minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- C. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the structure.
- D. Provide restraints for vertical and horizontal seismic motion in accordance with the seismic requirements in Section 26 05 00, Common Work Results for Electrical.

3.2 FIELD QUALITY CONTROL

- A. Check for damage and tight connections prior to energizing transformer.
- B. Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION

SECTION 26 24 16 PANELBOARDS

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. Distribution panelboards.
- B. Lighting branch-circuit panelboards.

1.2 REFERENCES:

- A. National Electrical Manufacturers Association (NEMA):
 - 1. PB-1-2006 Panelboards
 - 2. AB-1-2002 Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures
- B. National Fire Protection Association (NFPA):
 - 1. 70-2005 National Electrical Code (NEC)
 - 2. 70E-2004 Standard for Electrical Life Safety in the Workplace
- C. Underwriters Laboratories, Inc. (UL):
 - 1. 50-2003 Enclosures for Electrical Equipment
 - 2. 67-2003 Panel boards
 - 3. 489-2006 Molded Case Circuit Breakers and Circuit Breaker Enclosures

1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.
- B. Section 09 91 00, Painting: Identification and painting of panelboards.
- C. Section 26 05 00, Common Work Results for Electrical Systems: General electrical requirements and items that are common to more than one Section of Division 26.
- D. Section 26 05 33, Raceway and Boxes for Electrical Systems: Conduits and outlet boxes.
- E. Section 26 05 19, Low-Voltage Electrical Power Conductors and Cables: Cables and wiring.
- F. Section 26 05 26, Grounding and Bonding for Electrical Systems: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- G. Section 26 24 19.70, Integrated Transient Voltage Surge Suppressors (TVSS/SPDS) for Low Voltage Motor Control Centers.

1.4 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.5 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 SUBMITTALS

- A. Submit under provisions of Section 01 33 00, Submittal Procedures.
- B. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- C. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail bus configuration, current, and voltage ratings.
 - 3. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 4. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 6. Include wiring diagrams for power, signal, and control wiring.
 - 7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Include selectable ranges for each type of overcurrent protective device.
- D. Qualification Data: For qualified testing agency.
- E. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 26 05 00. Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- F. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- H. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 23 degrees F to plus 104 degrees F.
 - b. Altitude: Not exceeding 6200 feet.
- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Architect, Construction Manager, and Owner no fewer than two (2) days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Architect's and/or Owner's written permission.
 - 3. Comply with NFPA 70E.

1.10 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and form work requirements are specified in Division 03.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five (5) years from date of Substantial Completion.

1.12 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Two (2) spares for each type of panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two (2) spares for each panelboard.

PART 2 — PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.
- B. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.
 - 1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: NEMA 250, Type 3R
 - b. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - 7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. Incoming Mains Location: Top and bottom.
- D. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Neutral Bus: Neutral bus rated 100 percent of phase bus.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Compression type.
 - 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 - 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one (1) or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating:
 - 1. UL label indicating series-connected rating with integral or remote upstream overcurrent protective devices. Include size and type of allowable upstream and branch devices, listed

- and labeled for series-connected short-circuit rating by UL.
2. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches high, provide two (2) latches, keyed alike.
- D. Mains: As Noted On Drawings.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- G. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: As Noted On Drawings.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.

- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Automatic trip-free with inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I²t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 7. Arc-Fault Circuit Breakers: Single pole configurations as required for sleeping area circuits. Refer to drawings for circuit assignments.
 - 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Minimum interrupting rating as indicated by not less than:
 - (1) 120/208 Volt Panelboard: 10,000 amperes symmetrical.
 - (2) 120/240 Volt Panelboard: 10,000 amperes symmetrical.
 - (3) 277/480 Volt Panelboard: 14,000 amperes symmetrical.
 - c. Arc quenchers and phase barriers for each pole.
 - d. Quick-make, quick-break operating mechanisms.
 - e. Operating handle which indicates ON, TRIPPED and OFF positions.
 - f. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - g. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - h. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - i. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
 - 9. An overload on one pole of a multipole breaker shall automatically cause all the poles of the breaker to open.

2.5 SEPARATELY ENCLOSED MOLDED CASE CIRCUIT BREAKERS

- A. Where separately enclosed molded case circuit breakers are shown on the drawings, provide circuit breakers in accordance with the applicable requirements of those specified for panelboards.
- B. Enclosures are to be of the NEMA types shown on the drawings. Where the types are not shown, they are to be the NEMA type most suitable for the environmental conditions where the breakers are being installed

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 — EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NECA 407.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NECA 407.
- B. Installation shall be in accordance with the Manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- C. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 30 00.
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
 - 2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to panelboards.
 - 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- E. Comply with mounting and anchoring requirements specified in Section 26 05 29.
- F. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- G. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- H. Locate panelboards so that the present and future conduits can be conveniently connected. Coordinate the sizes of cabinets with designated space.
- I. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- J. Install filler plates in unused spaces.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- L. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53.
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53.
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53.
- E. Provide ARC flash identification per NFPA 70E.

3.4 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Panelboards will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 26 27 26 WIRING DEVICES

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. Switches
 - 1. General Purpose switches.
 - 2. Motor Rated switches

- B. Receptacles
 - 1. General purpose receptacles.
 - 2. Ground fault circuit interrupter receptacles.
 - 3. Special Purpose receptacles.
 - 4. Corrosion resistant receptacles.

- C. Device Plates
 - 1. Plastic.
 - 2. Metal.
 - 3. Cast metal.
 - 4. Weatherproof.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - 2. Federal Specifications (FS):
 - a. W-C-596, General Specification for Connector, Electrical, Power.
 - b. W-S-896F/GEN, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. WD 1, General Requirements for Wiring Devices.
 - 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 - 5. Underwriters Laboratories Inc. (UL):
 - a. 498, Standard for Attachment Plugs and Receptacles.
 - b. 508, Standard for Safety for Industrial Control Equipment.
 - c. 943, Standard for Ground-Fault Circuit-Interrupters.
 - d. 1449, Standard for Transient Voltage Surge Suppressors.

1.3 SUBMITTALS

- A. Action Submittals: Manufacturer's product data for wiring devices.

PART 2 — PRODUCTS

2.1 SWITCHES

- A. Switch, General Purpose:
 - 1. NEMA WD 1 and FS W-S-896F/GEN.
 - 2. 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. Color: White.

7. Automatic grounding clip and integral grounding terminal on mounting strap.
8. Manufacturers and Products, Industrial Grade:
 - a. Arrow Hart; 2221 Series.
 - b. Bryant; 4901 Series.
 - c. Hubbell; 1222Series.
 - d. Leviton; 1221 Series.

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. Enclosure/Mounting and Rating:
 - a. General Purpose:
 - (1) Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. UL 508 listed.
 - (2) General Purpose Rating: 30 amperes, 600V ac.
 - (3) Minimum Motor Ratings:
 - (a) 2 hp for 120V ac, single-phase, two-pole.
 - (b) 3 hp for 240V ac, single-phase, two-pole.
 - (c) 15 hp for 480V ac, three-phase, three-pole.
 - (4) Screw-type terminals.
3. Manufacturers:
 - a. General Purpose:
 - (1) Bryant.
 - (2) Hubbell.
 - b. Explosion-Proof: Eaton, Type B101.

2.2 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
7. Size: For 2-inch by 4-inch outlet boxes.
8. Industrial Grade:
 - a. Color: White
 - b. Manufacturers and Products:
 - (1) Arrow Hart; 5362 Series.
 - (2) Bryant; 5362 Series.
 - (3) Hubbell; 5362 Series.
 - (4) Leviton; 5362 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacles.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Color: White.
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.
6. Manufacturers:
 - a. Bryant.
 - b. Hubbell.
 - c. Arrow Hart.
 - d. Leviton.

C. Receptacle, Corrosion-Resistant (Chlorine Room only).

1. Meet requirements of general-purpose receptacles.

2. Nickel coated metal parts.
 3. Color: White.
 4. Manufacturer and Product:
 - a. Hubbell; 52CM62/53CM62
 - b. Leviton; 52CM-62/53CM-62.
- D. Receptacle, Special-Purpose:
1. Rating and number of poles as indicated or required for anticipated purpose.
 2. One matching plug with cord-grip features for each special-purpose receptacle.

2.3 DEVICE PLATES

- A. General: Sectional type plates not permitted.
- B. Plastic:
1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
 2. Color: To match associated wiring device.
 3. Mounting Screw: Oval-head metal, color matched to plate.
- C. Metal:
1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
 2. Finish: ASTM A 167, Type 302/304, satin.
 3. Mounting Screw: Oval-head, finish matched to plate.
- D. Cast Metal:
1. Material: Malleable ferrous metal or copper-free aluminum, with gaskets.
 2. Screw: Oval-head stainless steel.
- E. Weatherproof:
1. Receptacles, Weatherproof Type 1:
 - a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
 - b. Mounting Screw and Cap Spring: Stainless steel.
 - c. Manufacturers and Products:
 - (1) Crouse-Hinds; Type WLRD-1.
 - (2) Appleton; Type FSK-WRD.
 2. Receptacles, Weatherproof Type 2:
 - a. UL listed for WET location while in use.
 - b. Polycarbonate cover.
 - c. Locking type.
 - d. Manufacturers and Products: TayMac; Type Multi-Mac.
 3. Switches:
 - a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
 - b. Mounting Screw: Stainless steel.
 - c. Manufacturers and Products:
 - (1) Crouse-Hinds; DS-181 or DS-185.2
 - (2) Appleton; FSK-1VTS or FSK-1VS.

PART 3 — EXECUTION

3.1 SWITCHES

- A. Switch, General Purpose:
1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
 2. Install with switch operation in vertical position.
 3. Install single-pole, two-way switches so toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position so toggle is in up position when ON.
3. Install within sight of motor when used as a disconnect switch.

3.2 RECEPTACLES

A. Duplex Receptacles:

1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot up.
2. Ground receptacles to boxes with grounding wire only.
3. Weatherproof Receptacles:
 - a. Install in cast metal box.
 - b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.
5. Special-Purpose Receptacles: Install in accordance with manufacturer's instructions.

3.3 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. Engrave with designated titles.

F. Types (Unless Otherwise Shown):

1. Exterior:
 - a. Switch: Weatherproof.
 - b. Receptacle in DAMP location: Weatherproof Type 1.
 - c. Receptacle in WET location: Weatherproof Type 2.

G. Interior:

1. Flush Mounted Boxes: Metal.
2. Surface Mounted, Metal Boxes:
 - a. General Purpose Areas: Sheet Steel.
 - b. Other Areas: Cast.
3. Surface Mounted, Aluminum Boxes:
 - a. General Purpose Areas: Stamped.
 - b. Other Areas: Cast.
4. Surface Mounted, Sheet Steel Boxes: Raised sheet steel.
5. Surface Mounted, Nonmetallic Boxes: Manufacturer's standard.
6. Receptacle shown as Weatherproof on Drawings: Weatherproof Type 1.

END OF SECTION

SECTION 26 28 13 FUSES

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. This Section includes the following:
 - 1. Cartridge fuses rated 600V and less for use in switches.
 - 2. Spare-fuse cabinets.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.3 SUBMITTALS

- A. Product Data: Include the following for each fuse type indicated:
 - 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
- B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Division 1 include the following:
 - a. Let-through current curves for fuses with current-limiting characteristics.
 - b. Time-current curves, coordination charts and tables, and related data.
 - c. Ambient temperature adjustment information.
- C. Closeout: Submittals listed above, updated to record status.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NEMA FU 1.
- D. Comply with NFPA 70.
- E. Comply with the following standards:
 - 1. ANSI C97.1 - Low Voltage Cartridge Fuses 600 Volts or Less
 - 2. ANSI/UL 198C - High Interrupting Capacity Limiting Class L Fuses
 - 3. ANSI/UL 198E - Class R Fuses
 - 4. ANSI/UL 198G - Fuses for Supplementary Overcurrent Protection
 - 5. ANSI/UL 512 - Fuseholders

1.5 DESIGN REQUIREMENTS

- A. Select fuses to provide appropriate levels of short circuit and overcurrent protection for components such as wire, cable, bus structures, and other equipment. Design system to ensure that component damage is within acceptable levels during a fault.
- B. Select fuses to coordinate with time-current characteristics of other overcurrent protective elements, such as other fuses, circuit breakers, and protective relays. Design system to ensure that device closest

to fault operates.

1.6 FUSE PERFORMANCE REQUIREMENTS

- A. Motor Load Feeder Switches: Class RK1 (time delay).

1.7 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg. F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.8 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Quantity equal to ten percent of each fuse type and size, but no fewer than six of each type and size.

PART 2 — PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussman, Inc.
 - 2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Littelfuse, Inc.
- B. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.
- C. Voltage: Rating suitable for circuit phase-to-phase voltage.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 — EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures and elevation to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Intermixing of fuse type and manufacturers within the same series-connected circuit is prohibited.
- B. Fuse types (e.g. KRP-C & FRS) of the same manufacturer within the same series connected circuit is permitted and encouraged.

C. Motor Branch Circuits:

1. Standard motor circuits Class RK1, time delay.
2. Motor circuits for adjustable speed drives Class J, fast acting.

D. Branch Circuits: Class RK1, time delay.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is not up-side-down and readable without removing fuse.
- B. Fuse Blocks: Install fuses in fuse blocks rated for the respective fuse class.

3.4 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION

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SECTION 26 29 13.16 REDUCED-VOLTAGE MOTOR CONTROLLERS

PART 1 GENERAL

1.1 SCOPE OF WORK

- A. Furnish and install solid state starter as shown on the drawings and as specified herein, including all required appurtenances. The solid state starter shall be microprocessor controlled, suitable for use with three phase induction motors rated 600 VAC or less. The starter shall provide a closed loop current ramp for smooth and stepless motor acceleration and deceleration.

1.2 QUALITY ASSURANCE

- A. The solid state starter shall be the product of a manufacturer who has produced solid state starters of the same type and size for a minimum of 10 years consecutive. When requested by the Engineer, a Users List, complete with telephone numbers and contact persons shall be furnished for verification.
- B. For safety, reliability, and continuity of warranty, any modifications, alterations, etc. required to conform to the requirements of this specification shall be performed by the Starter Manufacturer only. Distributor modifications, third party packaging, etc. of a Manufacturer's standard product are specifically disallowed
- C. The solid state starter shall be designed, manufactured and tested to conform, where applicable, to the following industry standards and specifications:
 - 1. NEC
 - 2. UL
 - 3. CSA
 - 4. NEMA ICS2
 - 5. EEMAC
 - 6. OSHA
 - 7. IEEE
- D. Environmental Requirements:
 - 1. Temperature: 0 - 50-deg C (32° F to 140° F Min.)
 - 2. Relative Humidity: up to 95%, non-condensing
 - 3. Input Power: 480V AC, 3 Phase, +/- 10% 50-60 Hz, +/- 3 Hz.
 - 4. Meet Uniform Building Code on non-building structures, section 2338 for zone 1, 2, 3, and 4 requirements.

1.3 SUBMITTALS

- A. Submittals shall be furnished in accordance with Specification Section 01 33 00 - Submittal Procedures.
- B. Provide the following:
 - 1. Elementary wiring and interconnection diagrams in accordance with NEMA ICS standards.
 - 2. Size, type, and rating of all system components
 - 3. Enclosure frontal elevation and dimension drawings.
 - 4. Internal component layout diagrams.
 - 5. Available conduit entry and exit locations.
 - 6. Manufacturer's product data sheets.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Handling and shipment of the equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
- B. Equipment shall be stored indoors in a clean, dry environment. Energize space heaters if furnished.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Benshaw, Inc.
- B. Motortronics.
- C. Or Engineer approved equal meeting the detailed requirements of this specification

2.2 EQUIPMENT DESIGN CRITERIA

- A. Size:100 HP
- B. Minimum Overload Rating: 500% of Starter FLA for 30 sec., 125% cont.
- C. PIV Ratings:1800V Minimum
- D. Rated Short Circuit Amps:42KAIC
- E. Insulation Test:2500VAC Minimum
- F. Overall Efficiency w/o Bypass: Average 99.7%
- G. Overall Efficiency w/Bypass: 99.94%
- H. SCR Firing Technique :Hard Drive with "picket fence"
- I. Transient Voltage Protection: dV/dT circuits or SIOV/ phase
- J. Under voltage Protection: 80% Pickup; 60% Dropout
- K. Control Input: Dry contact, 2 wire.
- L. Starts Per Hour: Minimum of 5
- M. Min Time Between Restarts: Not more than 2 minutes
- N. Audible Noise: Not to exceed 60dba @ 1 meter at any time

2.3 ENCLOSURE CONSTRUCTION

- A. Construct to comply with NEMA Part ICS 2.
- B. Basic structure shall be welded type construction utilizing minimum 14 GA sheet metal.
 - 1. Doors shall be minimum 14 GA sheet metal, pan type with flanges formed to provide sturdy, rigid structure.
 - 2. Door latches and hinges capable of holding door closed during maximum fault condition.
 - 3. Provide defeatable door interlocks to prevent doors from being opened with power applied
 - 4. Provide removable lifting provisions on floormount enclosures.
 - 5. Each structure shall be provided with removal lifting provisions.

- C. The starters and any required accessories or auxiliary items shall fit within the space shown on the Plans
- D. Finish:
 - 1. Metal parts to be given thorough rust resistant treatment.
 - 2. Primer shall be S-W recoatable epoxy primer B-67 Series
 - 3. Finish shall be S-W high solid polyurethane polate T plus F63 series
 - 4. Color shall be ANSI 61
- E. Complete with internal power and control wires including terminations for external connections. Phase sequencing shall have proper identification and control wires shall have suitable markings at terminations.

2.4 MAIN AND BYPASS CONTACTORS

- A. Inline (main) contactor and a bypass contactor shall be provided.
 - 1. Full NEMA rated (IEC rated contactors cannot be accepted)
 - 2. Current rating: manufacturer standard for horsepower rating .
 - 3. Voltage rating: Up to 600 VAC.
 - 4. The main, bypass, and capacitor contactors shall be sequenced by the starter manufacturer for proper operation of the solid state starter.
 - 5. The bypass contactor shall bypass the SCR's after starting and while the starter is in the run (full voltage) mode.

2.5 CONSTRUCTION

- A. Enclosure Construction:
 - 1. The starter cabinet shall contain the following:
 - a. NEMA rated inline and bypass contactors.
 - b. Low voltage control devices.
 - c. Auxiliary metering and control devices as specified herein or as shown on the Contract Drawings
 - d. Power factor correction capacitor rated for 95% Power Factor.
 - e. Contactor to apply power factor correction capacitor after RVSS bypass contactor is closed.
- B. Power Fuses:
 - 1. Current limiting type rated 42KAIC symmetrical at max. 600V.
 - 2. Fuse size shall be manufacturer's standard.
 - 3. Fuses shall be vertically mounted in the front of the enclosure for ease of inspection and removal without special tools.
 - 4. Provide blown fuse indication.
 - 5. Power fuse holders shall be part of starter assembly.
- C. SCR Stacks:
 - 1. Arranged horizontally for proper heat management.
 - 2. Heat sinks sized for specified Starts Per Hour without requiring auxiliary cabinet cooling fans.

2.6 CONTROL DEVICES

- A. Control Power Transformer
 - 1. Provide an appropriately rated internal 480V-120VAC step-down transformer.
 - 2. Supply two fuses on primary and one fuse on secondary side with one leg

grounded.

- B. Control Wiring: minimum 16 GA stranded, rated for 600 V.
- C. Terminal Strips: Rated for 600 V, suitable for contractor termination of up to 10 GA wire.
- D. Push buttons, pilot lights, and control relays, heavy duty, rated to 600 V.

2.7 SOLID STATE STARTER LOGIC CONTROL

A. Provide a door mounted Display & User Interface Module with the following functions:

- 1. Backlit LCD- 2 Lines, 16 Characters
- 2. Tactile Feedback Buttons
- 3. Pass Code Protection
- 4. Battery Backup of Starter Parameters & Diagnostics
- 5. Built in Start/Stop Pushbuttons
- 6. Status Indication via LCD Display and LED's
- 7. Scrolling Menu/Parameters
- 8. Discrete Enter Command Button
- 9. Meter Mode Display
- 10. Selectable Meter Mode Scroll Rate
- 11. Main Display Hot Key

B. Provide a Windows based software package with the Solid State Starters included under this contract for use on an Owner furnished IBM compatible PC. The software shall be utilized to program and monitor the starter parameters listed in paras. C-G without exception. The software shall include the following features and functions:

- 1. Connect to Starters via RS232 or RS485 port
- 2. Display up to six (6) starters at a time as screen Icons
- 3. Provide realtime starter basic parameter feedback
- 4. Provide realtime Start and Stop capabilities
- 5. Provide realtime current trending chart display for each starter
- 6. Provide capability for full Starter parameter programming
- 7. Provide an Event Recorder Display
- 8. Provide a Fault Recorder Display
- 9. Provide a comparison of Setup parameters to Last Start conditions
- 9. Comm speed of up to 9600 baud

C. Programmable Motor Control Functions.

- 1. Motor Starting/Running
 - a. Programmable Current Ramp
 - b. Ramp to Limit
 - c. Dual Ramps
 - d. Full Voltage Start
 - e. Initial Current Limit (50-400%)
 - f. Motor Service Factor (1.0, 1.15, or 1.25)
 - g. Start Ramp Time (0-120 Sec.)
 - h. Power Outage Ride Through
 - i. Dual Kick Start (0.1-10 Seconds)
 - j. Programmable 1-1200 Amps
 - k. Maximum Current (200-600%)
- 2. Motor Stopping
 - a. Fully Programmable "S" Curve Pump Decel
 - b. Soft Stop
 - c. Fail Soft on Motor Overload
 - d. Auxiliary Motor Feeder Control
- 3. Interlocking/Logic
 - a. Restart Block-Backspin Timer
 - b. Overload Lockout

- c. General Fault Digital Relay Output
 - d. Assignable Digital Relay Outputs (2)
 - e. Frequency Tracking
 - f. Up to Speed Indication/Contact
 - g. Preassigned Digital Inputs (7)
 - h. User Selectable # of Auto Restarts
 - i. User Selectable Fault Priority
 - j. Fully Programmable 4 output Relay Cards
4. Maintenance
- a. Emergency Restart After Fault Lockout
 - b. Selectable CT Ratios
 - c. Current Limited Jog
 - d. Event Recorder

D. Programmable Motor Protection Functions

- 1. Motor/Machine Faults
 - a. Electronic Overload
 - b. Selectable Overload Curves, Class 10/20/30
 - c. Overload Reset
 - d. Overload Warning
 - e. Acceleration Time
 - f. Instantaneous Overcurrent
 - g. Mechanical Jam/Electronic Shearpin (Selectable Trip or Warning)
 - h. Motor Thermal Capacity Protection
 - i. Undercurrent Alarm (Selectable Trip or Warning)
 - j. Time Between Restarts
 - k. Trip Reset Protection
 - l. Machine Ground Fault Protection (Selectable Trip or Warning)
- 2. Electrical System Faults
 - a. Undercurrent Protection
 - b. Current Unbalance (10-40%)
 - c. Overfrequency Protection
 - d. Overload Alarm
 - e. Undervoltage Protection (10-30%)
 - f. Generator Set Frequency Tracking
 - g. Overvoltage Protection (10-30%)
 - h. Restart After Non-critical Fault
 - i. Phase Reversal Protection
 - j. Ground Overcurrent Protection
 - k. Underfrequency Protection

E. Diagnostics Functions

- 1. Alpha/Numeric Fault Display
- 2. Starter Status Indication
- 3. Revolving 99 Most Recent Events
- 4. Pre-Start: Pending Fault Indication
- 5. Start/Stop Recorder
- 6. Pre-Start: Phase Rotation Indication
- 7. Date & Time Stamped Events
- 8. Control Board Built in Self Tests
- 9. Motor Thermal % Capacity Display
- 10. Shorted SCR Detection
- 11. Closed Loop Motor Stall Detection
- 12. LED Indication SCR Status
- 13. Open Loop Motor Stall Detection
- 14. Full Screen Meter Mode

F. Metering Functions

1. Meter Displays:
 - a. Scrolling Current 1.% Overload
 - b. Elapsed Time Meter
 - c. Average Current, Current: L1, L2 & L3
 - d. Percent Current Imbalance
 - e. Ground Fault Current
 - f. Elapsed HourX100 Meter
 - g. Kilowatts, kilowatt Hours, Megawatt Hours
 - h. Scrolling Voltage
 - i. Voltage: Average, L1, L2 & L3
 - j. KVAR
 - k. KVA
 - l. Starts Counter
 - m. Line Frequency (60Hz)
2. Programmable Relay Outputs
 - a. Programmable Relay Outputs
 - b. Overload
 - c. Ground Fault
 - d. Overload Lock
 - e. Shear Pin Trip
 - f. Overload Warn
 - g. Under Current Trip
 - h. Run
 - i. Brake Mode
 - j. Up To Speed
 - k. Starter Ready
 - l. Shorted SCR
 - m. Shunt Trip

PART 3 EXECUTION

3.1 TESTING.

- A. All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.
- B. Power semiconductors shall be fully tested for proper electrical characteristics, including dv/dt and di/dt.
- C. All subassemblies shall be inspected and/or tested for conformance to quality assurance specifications.
- D. Each completed unit shall be functionally tested prior to shipment to assure conformance to the specifications.

3.2 STARTUP & TRAINING

- A. Bid price shall include 1 - day site visit, consisting of startup and training. Services shall include startup of equipment and field training for owner's personnel. Startup and training shall be provided by factory direct personnel only. The use of agents, manufacturer's representatives, associated integrators or manufacturer's distributors for startup and training shall not be permitted.

3.3 WARRANTY

- A. Starters furnished herein shall include a three (3) year manufacturer's warranty (from date put in service) on all solid state power sections and P.C.solid state control cards with one (1) year manufacturer's warranty (from date put in service) on other equipment of each system.

3.4 SPARE PARTS

- A. A complete set of Spare Parts shall be provided at no extra cost to the Owner. Spare parts shall include, but not be limited to:
1. One each of each type of Printed Circuit Board.
 2. One of each type and size of control fuse.
 3. Three of each type and size of power fuse.
 4. One complete spare Power Cell of each type and size used.

END OF SECTION

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SECTION 26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. This section includes requirements for individually mounted and enclosed fused and non-fused disconnect switches, fuses, and circuit breakers for disconnecting and protecting services, feeders, branch circuits, and utilization equipment.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this section.

1.3 REFERENCES

- A. The latest edition of the following standards and codes, standard publications of professional organizations, and the local authorities having jurisdiction are the minimum requirements for this work.
 - 1. American National Standards Institute (ANSI)
 - 2. Institute of Electrical and Electronic Engineers (IEEE)
 - 3. National Electrical Manufacturer's Association (NEMA)
 - 4. National Fire Protection Association (NFPA)
 - 5. NFPA 70, the National Electrical Code (NEC)
 - 6. Underwriters Laboratories, Inc. (UL)
 - 7. State, city, and local authorities

1.4 DEFINITIONS

- A. FDS: Fused Disconnect Switch
- B. NFDS: Non-fused Disconnect Switch
- C. RMS: Root Mean Square
- D. SPDT: Single-pole Double-throw

1.5 SUBMITTALS

- A. General:
 - 1. Submit each item in this Article according to the Conditions of the Contract and Division 1 Specifications.
 - 2. All exceptions to this specification shall be given in written format referencing the section and paragraph and stating the proposed alternative to the requirement.
 - 3. The information continued in the submittal shall be complete in every respect, as partial submittals shall be cause for rejection.
- B. Product data for disconnect switches, circuit breakers, and accessories specified in this section as follows:
 - 1. Descriptive data and ratings for voltage, continuous current, maximum horsepower, and short-circuit rating
 - 2. Dimensional plans, elevations, sections, and details
 - 3. NEMA enclosure type and size.
 - 4. Cable terminal size, number, and material
 - 5. Unit wiring diagrams depicting local and remote devices.
 - 6. Accessories device descriptive bulletins and product data sheets (i.e. shunt trip coil, undervoltage release, ground fault, auxiliary contacts, key interlocks, etc.)

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70, the National Electrical Code.
- C. All equipment and materials will be new and unused and shall conform with the current applicable industry standards. Workmanship and neat appearance shall be as important as electrical and mechanical operation. Defective or damaged materials shall be replaced or repaired prior to final acceptance in a manner meeting approval of Architect and/or Engineer and at no additional cost to the Owner.

PART 2 — PRODUCTS

2.1 MANUFACTURERS

- A. Disconnect Switches and Circuit Breakers: Acceptable manufacturers are listed below. All disconnect and circuit breakers shall be of the same manufacturer.
 - 1. Eaton
 - 2. General Electric Company
 - 3. Siemens
 - 4. Square D Company
- B. Fuses: Acceptable manufacturers are listed below. All fuses shall be of the same manufacturer.
 - 1. Cooper Bussman, Inc.
 - 2. Ferraz Shawmut, Inc.
 - 3. Tracor, Inc.; Littelfuse, Inc. Subsidiary

2.2 DISCONNECT SWITCHES

- A. Enclosed fusible and non-fusible switches, 1200-amp and smaller, NEMA KS1, heavy duty type with lockable handle, 600-volts, horsepower rated for motors as required. Number of poles and ampacity as noted or required by Code. Short-circuit rating shall be sufficient to withstand the available fault current or let-through current before the fuse melts without damage or change in rating.
- B. Fusible switches 30- through 600-amperes shall be furnished with rejection class "R" or "J" type fuse clips and 800 through 1200 amperes shall be furnished with class "L" type fuse clips.
- C. Switches shall incorporate a safety cover interlock to prevent opening the cover with the switch in the "ON" position or prevent placing the switch in the "ON" position with the cover open. Provide a "defeater" for authorized personnel.
- D. Handles shall have provisions for padlocking and shall clearly indicate the ON and OFF positions. Front cover doors shall be padlockable in the closed position.

2.3 CIRCUIT BREAKERS

- A. General:
 - 1. Provide 600-volt enclosed molded case circuit breaker per NEMA AB1 with lockable handle with frame size, trip rating, number of poles, and interrupting rating to meet available fault current. Application listing shall be appropriate for switching fluorescent lighting loads or heating, air conditioning, and refrigerating equipment.
 - 2. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-breaker over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to

- exercise the trip mechanism.
 - 3. Thermal-magnetic Circuit Breakers: Frame sizes 400 amp and smaller shall have inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 amp and larger.
 - 4. Molded-case Switch: Molded-case circuit breaker without trip units.
- B. Circuit-breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
- 1. Lugs: Mechanical style suitable for number, size, and material of conductors.
 - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

2.4 ENCLOSURE

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
- 1. Indoor Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4

PART 3 — EXECUTION

3.1 INSTALLATION

- A. Install devices in general area of equipment and accessible to maintenance personnel according to manufacturer's written instructions. Secure devices firmly to supporting structure with approved fasteners in a level and plumb manner. Verify voltage and amperage size and enclosure type of devices for each installation. Where practical, devices shall be mounted such that the top of switch is a maximum of 61-0" above finished floor or surface.
- B. Connect devices to wiring system and to ground as indicated and instructed by manufacturer. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- C. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse. Install labels indicating fuse replacement information on inside door of each fused switch.
- D. Identify each device according to requirements in other sections of these specifications.

3.2 OVERCURRENT PROTECTIVE DEVICES

- A. Install fuses where required as a protective device in conformance with equipment manufacturer's specified requirements and in accordance with the requirements of this section.

3.3 EQUIPMENT CONNECTIONS

- A. Provide all final power connections for mechanical equipment. All equipment items will be furnished and set by others. Confirm with suppliers all rough-in data, e.g., electrical characteristics, dimensions, locations, type of connection, etc., prior to installation.

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
- 1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
 - 2. Test continuity of each line- and load-side circuit.
- B. Testing: After installing and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
- 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in

NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.5 ADJUSTING

- A. Set field-adjustable switches and circuit breaker trip ranges.

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of enclosures. Remove paint and plaster splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION

SECTION 26 50 00 LIGHTING

PART 1 — GENERAL

1.1 SECTION INCLUDES

- A. Interior lighting fixtures and accessories.
- B. Emergency lighting systems.

1.2 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. ANSI C62.41 IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- B. American Society for Testing and Materials (ASTM):
 - 1. ASTM A123/A123M Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2. ASTM A167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - 3. ASTM A366/A366M Specification for Steel Sheet, Carbon, Cold-Rolled, Commercial Quality
- C. Federal Specifications (FS):
 - 1. TT-P-641 Type II Zinc Dust Primer for Steel or Galvanized Metal Surfaces
- D. Illuminating Engineering Society of North America (IES):
 - 1. IES Lighting Handbook, Reference and Application
- E. National Fire Protection Association (NFPA):
 - 1. NFPA 101 Code for Safety to Life from Fire in Buildings and Structures
- F. Porcelain Enamel Institute (PEI):
 - 1. PEI S-100 Specification for Architectural Porcelain Enamel on Steel for Exterior Use
 - 2. PEI LS-105 Specification for Architectural Porcelain Enamel on Aluminum for Exterior Use
- G. Underwriters Laboratories Inc. (UL):
 - 1. UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
 - 2. UL 496 Edison-Base Lampholders
 - 3. UL 508 Industrial Control Equipment
 - 4. UL 542 Fluorescent Lamp Starters
 - 5. UL 595 Marine-Type Electric Lighting Fixtures
 - 6. UL 773 Plug-In, Locking Type Photocontrols for Use with Area Lighting
 - 7. UL 1029 High-Intensity-Discharge Lamp Ballasts
 - 8. UL 1571 Incandescent Lighting Fixtures
 - 9. UL 1572 High Intensity Discharge Lighting Fixtures
 - 10. UL 8750 The Standard for Safety of Light Emitting Diode (LED) Equipment for use in Lighting Products.

1.3 RELATED SECTIONS

- A. Section 01 33 00 - Submittal Procedures.

1.4 SUBMITTALS

- A. Product Data Luminaire Manual: Submit light fixture manual which provides product data indicating fixture construction, photometric performance, installation, and maintenance requirements. Include the following information and exhibits:
1. The Manual shall be complete with cover, title page, and table of contents. The cover and title page shall identify the document, project, client, contract name, number and date of issuance. The table of contents shall provide at a glance the overall document scope and structure and, as a minimum, a heading for each fixture type with each grouping prefaced by a "general information" report sheet.
 2. The Manual shall include drawings and illustrations of sufficient detail to show the following:
 - a. Fixture housing, hardware, and finishes;
 - b. Lighting controlling elements;
 - c. Electrical components, including lampholders, ballast, and provision for conduit entry; and
 - d. Support details including foundation. Indicate weight of fixture, complete with lamps.
 3. The Manual shall include procedures for installation of the complete lighting unit in its final service location. Provide templates for mounting of light poles. Provide dimensions to locations of openings and parts interfacing with remote systems, such as pole bases, mounting hardware, auxiliary electrical equipment, lighting control equipment, and lamps.
 4. The Manual shall include operation and maintenance requirements in accordance with
 - a. Materials and components clearly indicated in the parts list;
 - b. Re-lamping methods;
 - c. Special tools required; and
 - d. Frequency of inspection, tightening, or other service recommended for preventative maintenance.
 5. The Manual shall include calculations indicating capability of light poles with light fixtures installed to withstand wind load requirements. Proper selection of anchor bolts shall be included in the computation.
- B. Test Reports: Submit certified test reports of factory and field tests performed, in accordance with applicable referenced standards and Specification requirements.
- C. Samples: Submit one complete light fixture or luminaire for each type required. Each sample requires the Engineer's approval and shall become the property of the District. Approved samples will become the Engineer's control samples.

1.5 GENERAL REQUIREMENTS

- A. Determine required quantities of equipment from Drawings.
- B. Systems shall be complete and operable including required accessories, fastenings, and supports.

1.6 DELIVERY, HANDLING, AND STORAGE

- A. Handle and transport products in a manner that prevents damage.
- B. Wrap and package products to avoid damage.
- C. Indelibly mark each carton with minimum 1/2 inch high letters containing the following information:
 1. Fixture, lamp, or component type.
 2. Quantity.
 3. Manufacturer's name and product number.
- D. Store products in a clean, dry, and secure storage area pending installation.

1.7 JOBSITE CONDITIONS

- A. Install new lamps not earlier than 48 hours before the date of final inspection.
- B. Install exposed parts of fixtures after construction, painting, and general cleanup in the area have been completed.

- C. Inspect surfaces and structures to, and on, which products will be installed before the work of this Section begins, and ensure that these surfaces are capable of supporting the products. Surfaces that will be concealed by products shall be finished before products are installed.

PART 2 — PRODUCTS

2.1 LIGHTING FIXTURES

- A. Types: As designated in "Lighting Fixture Schedule" on Drawings.
- B. Requirements:
1. Provide lighting fixtures, complete and ready for service, in accordance with UL 1570, UL 1571, and UL 1572. Fixtures shall be of the number, type, material, finish, electrical components, and characteristics, and shall be provided with the necessary hardware and auxiliary equipment, as indicated. Light fixtures provided with provisions for raceways shall be UL-listed for this use. Comply also with applicable requirements and guidelines of the IES Lighting Handbook.
 2. Mark fixtures clearly with manufacturer's name and catalog number, voltage, acceptable lamp type, maximum wattage, and label for intended use.
 3. Fixtures shall be UL listed for the location and application indicated.
- C. Materials:
1. Thicknesses, gages, and tempers of products shall be as indicated, and as recommended by the manufacturer for the specific finish, proper forming operations, and structural requirements.
 2. Reflector material shall be prefinished, copper-free aluminum alloy, minimum thickness 0.032 inch, Architectural Type 1 with Class M1 anodic coating providing 83 percent reflectivity.
 3. Acrylic for lenses and diffusers shall be manufactured from virgin-acrylic extrusion or injection molding pellets.
 4. Glass for lenses shall be of tempered borosilicate pressed or spun glass, minimum 0.13 inch thick.
 5. Stainless steel shall be Type 304 conforming to ASTM A167.
- D. Finishes:
1. Provide lighting fixtures completely factory-finished in colors to match the Engineer's control samples.
 2. Do not start finishing operations until fabrication and forming operations have been completed.
 3. Aluminum to be anodized shall be given the Aluminum Association's Architectural Class 1 anodic coating.
 - a. Anodize aluminum in accordance with procedures established by alloy manufacturer to achieve color within specified range.
 - b. Apply a clear organic protective coating to exposed aluminum surfaces that may experience prolonged contact with caustic material such as concrete and plaster.
 4. Minimum cleaning of metal before painting shall be a five-stage phosphatizing system consisting of alkali cleaner, hot water rinse, zinc phosphatizing solution with toner, water rinse at room temperature, and chromic acid rinse for neutralizing.
 5. Interior fixtures with surfaces not exceeding 150 degrees F shall be statically charged and painted two coats minimum of acrylic gloss enamel to a minimum total dry film thickness (DFT) of 2.5 mils.
 6. Interior fixtures with surfaces exceeding a temperature of 150 degrees F, but not exceeding 300 degrees F, shall be statically charged and painted with silicone-alkyd enamel, two coats minimum to a total DFT of 2.5 mils.
 7. Provide fixtures specified to be painted with one coat of epoxy-polyamide at a minimum DFT of 2 mils and one coat of aliphatic urethane to a minimum DFT of 2 mils. Interior reflective surfaces specified to be painted shall be as for interior fixtures.
 8. Finish fixtures specified to be porcelain enameled, or painted fixtures with reflectors specified to be porcelain enameled, shall receive porcelain-enamel coating in accordance with the requirements of PEI S-100 or PEI LS-105.
 9. Reflective surfaces not specified to be specular shall be gloss white, guaranteed nonyellowing, with a reflectance rating of not less than 88 percent.
 10. Provide galvanized coating, where indicated, hot-dip galvanized according to ASTM A123.

Where painting of the galvanized surface is indicated, pre-treat the surface with a spray of zinc chromate-vinyl butyryl wash primer at least 0.05 mil thick; apply an 80 percent zinc dust, 20 percent zinc oxide, alkyd resin primer conforming to FS TT-P- 641; and then apply a single-component, Type II, modified acrylic or polyurethane top coat.

E. Electrical Components

1. Fixture Wiring:
 - a. Provide fixture wires of stranded tinned-copper construction, not smaller in wire size than 16 AWG. Provide insulation of silicone rubber type SF-2, 200 degrees C rated. Mark conductor size, temperature rating, voltage, and manufacturer clearly on the insulation of each conductor.
 - b. Tape wires at points of abrasion. Do not permit splices within fixtures other than as required to connect lampholders and ballast. Provide wireways and wiring channels with rounded edges or bushed holes wherever conductors pass through. Install insulated bushings at points of entrance and exit of wiring.
2. Fixture Grounding:
 - a. Unless otherwise specified, provide the housing of each ballasted lighting fixture with a separate, factory-installed grounding device.
 - b. A separate grounding conductor shall be attached to the grounding device on each fixture housing and connected to the ground lug terminal in the hand hole of the light pole.
 - c. Provide only GRS conduits and accessories, except in underground or concrete encased duct banks.
 - d. Light poles shall be grounded by use of a separate grounding conductor connected at one end to the grounding lug in the hand hole of each pole, and the other end connected to the grounding bus in the lighting distribution panel.

F. Fixture Hardware:

1. Latch and release mechanism, hinges, pins, and other retaining parts of fixtures; screws, bolts, or other assembly and mounting parts shall be manufactured of Type 304 or Type 316 stainless steel. Provide springs of heavy-duty stainless steel. Provide self-retaining type retaining hardware.
2. Light transmitting panels shall be held in the frames in a neat, rattle-free manner that will provide proper tolerance for normal expansion and contraction.
3. Fabricate internal brackets from ASTM A366/A366M sheet steel, zinc-coated after fabrication, or finished extruded aluminum.
4. Gaskets, sealants, and adhesives shall be formed from silicone rubber.
5. Provide bolts, nuts, washers, screws, nails, rivets, and other fastenings necessary for proper installation or assembly of work. When exposed to the atmosphere, items shall be made of 300 series stainless steel. Fastenings within the housing shall be hot-dip galvanized steel. Nuts shall have captive externally-footed lockwashers.
6. Junction boxes suitable for the intended location and wiring requirements shall be provided with four 3/4 inch threaded and plugged conduit entries.

- G. Lighting fixtures shall be furnished completely assembled with wiring and mounting devices, and be ready for installation at locations noted. Recessed fixtures in suspended ceilings shall be designed and equipped for installation in type of ceiling in which fixture is to be installed. Fixtures shall be designed to be supported independently of ceiling.

2.2 LIGHT EMITTING DIODE (LED) LIGHTING

The LED Fixture shall consist of a LED Luminaire Assembly, LED Driver and mounting hardware.

A. LED Lighting Fixture

LED Fixture requirements are as described below:

1. The input to the LED Lighting Fixture shall be 120 to 277VAC ($\pm 10\%$), 60HZ or as indicated in the Contract Document.
2. Correlated Color Temperature (CCT) shall be minimum 4000K or as indicated in the Contract Document.

3. Color Rendering Index (CRI) shall be 70.
4. A minimum of 50,000 operating hours before reaching the L70 lumen output degradations point without catastrophic failure, or as indicated in the Contract Document.
5. Conform with UL 8750.
6. Compliance to FCC CFR Section 15.

B. LED Luminaire Assembly

Luminaire Assembly requirements as described below:

1. Definition: Luminaire Assembly is the LED assembly without LED driver.
2. Input voltage shall be 24VDC, 36VDC or as indicated in the Contract Document.
3. CCT, CRI, Minimum life and UL conformity requirements are as defined in above article LED Lighting Fixture.

C. LED Driver

LED Driver requirements are as described below:

1. Must operate input voltage between 120VAC to 277VAC ($\pm 10\%$).
2. Operating frequency must be 60Hz.
3. Must be rated to operate between -40°C to $+50^{\circ}\text{C}$.
4. Must have a minimum efficiency of 85%.
5. Self protected including short circuit protection.
6. Compliance to FCC CFR Section 15.
7. Driver must have a Power Factor (PF) of ≥ 0.90 .
8. Types and ratings: As shown on "Lighting Fixture Schedule" on Drawings.

2.3 FIXTURE MOUNTING HARDWARE

A. Requirements:

1. Provide fixtures with brackets, straps, canopies and stems, poles, and miscellaneous hardware suitable for the mounting method specified. Pendant mounted fixtures shall have seismic resistant swivel mountings.
2. When exposed to public view, fabricate and finish hardware in material matching the fixture body.
3. Canopies, holders, and similar parts shall be drawn or spun in one piece with a minimum 0.026 inch finished thickness.
4. Tubing used for stems shall be seamless drawn with a minimum of 1/16-inch wall thickness of size and length as indicated. Stems shall be provided for pendant-mounted fixtures of length as required for the specified mounting height with swivel hangers or ball aligners.

PART 3 — EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Determine locations and arrangement of equipment from Drawings.
- B. Locations shown on Drawings are approximate unless dimensioned. Choose precise location to clear obstructions and to provide sufficient space for operation and maintenance.
- C. Coordinate timing of installation and location of equipment with other trades.
- D. Make permanent lighting system, or selected portions thereof, operable as soon as possible.
- E. Install equipment in strict accordance with manufacturer's recommendations.
- F. Perform construction in accordance with NEC.
- G. Repair factory finishes where they become damaged during construction.
- H. Install equipment level and plumb.

3.2 LIGHTING FIXTURES

- A. Support lighting fixtures from building framing or floor slabs, and independently of conduit system and suspended ceilings.
- B. Coordinate exact locations of lighting fixtures with suspended ceiling layout to achieve uniformity.
- C. To minimize equipment breakage, delay installation of lighting fixtures in locations near heavy piping and equipment until such equipment is in place.
- D. Replace defective or damaged lighting fixtures and lamps at conclusion of job.

3.3 WALL-MOUNTED EQUIPMENT

- A. Concrete or masonry walls: Use expansion anchors and bolts; install collars around mounting bolts, or use other means to provide air space between wall and equipment enclosure.
- B. Structural steel mounting: Bolt to steel or brackets attached to steel; provide air space between steel and equipment enclosure.

3.4 LIGHTING CONTROLS

- A. Mount photocells facing north or upward and adjust to render insensitive to any artificial lighting units.
- B. Install occupancy sensors and ambient light sensor in accordance with manufacturer's installation procedures. Final adjustments of sensors shall be coordinated with Owner for proper settings.

3.5 FIELD QUALITY CONTROL

- A. Inspect luminaires, lamps, and associated hardware before and after installation to ensure that they are of the quality and type specified and indicated, and are free of defects and damage.
- B. Deliver luminaires and lighting equipment to the project site complete with related items, completely wired and assembled.
- C. Whenever practicable, test lighting systems at the same time that the distribution panelboard or switchboard is tested.
- D. Replace failed fixtures within 2 years days after final acceptance without additional cost to the District.
- E. Test light poles for continuity to the grounding system.

END OF SECTION



SECTION 31 37 00 RIPRAP OR ROCK LINING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. This section covers furnishing and placing the granular filter and loose riprap materials in accordance with these specifications and in conformity with the lines, grades, and dimensions shown on the drawings or as directed by the ENGINEER.

1.2 RELATED WORK

- A. APWA Section 31 05 19 – Geotextiles

1.3 REFERENCES

- A. The latest edition of the following publications form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.
- B. American Society for Testing and Materials (ASTM)
 - ASTM C-127 Specific Gravity and Absorption of Coarse Aggregate.
 - ASTM C-535 Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.4 SUBMITTALS

- A. The following shall be submitted:
 1. Certification from a certified independent laboratory that the riprap meets the material properties of this specification.
 2. A sample of the riprap to be used for construction.

1.5 STORAGE OF MATERIALS

- A. Materials shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials.

PART 2 - PRODUCTS

2.1 8 OZ NON-WOVEN STABILIZATION-SEPARATION GEOTEXTILE

- A. Woven fabric. Meet the following properties and survivability ratings.

Stabilization-Separation Geotextiles					
Property	ASTM	MARV			
		Moderate		High	
		Woven	Non-woven	Woven	Non-woven
Grab Tensile Strength, lbs.	D 4632	180	115	270	180
Grab Elongation, percent	D 4632	<50	>50	<50	>50
Trapezoid Tear, lbs.	D 4533	70	40	100	75
Puncture Resistance, lbs.	D 4833	70	40	100	60
Apparent Opening Size, (AOS-US Sieve)	D 4751	≥ 30	≥ 60	≥ 30	≥ 60



Construction Survivability						
Subgrade, CBR	1		1-2		≥2	
Tire Pressure, psi	<50	>50	<50	>50	<50	
6 inches Cover Thickness	NR	NR	H	H	M	M
12 inches Cover Thickness	NR	NR	H	M	M	M
18 inches Cover Thickness	H	M	M	M	M	M

Where H = High; M = Medium; NR = Not Recommended

2.2 LOOSE RIPRAP

- A. Riprap shall consist of quarry stone which is sound and durable against disintegration under conditions to be met in handling and placing, and is hard and tenacious and otherwise of suitable quality to ensure permanency in the specified kind of work.
- B. Riprap sources shall be approved the ENGINEER prior to use. Concrete masonry or concrete pavement may not be used for riprap. Riprap shall be well graded with additional gradation requirements for riprap as follows:

LOOSE RIPRAP GRADATIONS

Riprap Designation	% Smaller Than Given Size By Weight	Least Dimension (inches)	D ₅₀ ** (Inches)
Class I	70-100	12	6
	50-70	9	
	35-50	6	
	2-10	3	
Class II	70-100	15	9
	50-70	12	
	35-50	9	
	2-10	3	
Class III	70-100	20	12
	50-70	16	
	35-50	12	
	2-10	4	
Class IV	70-100	25	15
	50-70	20	
	35-50	15	
	2-10	5	
Class V	70-100	30	18
	50-70	24	
	35-50	18	
	2-10	6	
Class VI	70-100	35	21
	50-70	28	
	35-50	21	
	2-10	7	
Class VII	70-100	40	24
	50-70	32	
	35-50	24	
	2-10	8	

** D₅₀ = Nominal particle size



- C. All stones shall be angular (no rounded rock will be permitted), each piece having its greatest dimensions not greater than three times its least dimensions. All stone shall conform to the following test requirements of the American Society for Testing and Materials Standards:

	<u>Requirements</u>	<u>ASTM Standard</u>
Specific Gravity, minimum	2.60	C-127
Los Angeles Abrasion, maximum percent	40	C-535

- D. The CONTRACTOR shall be responsible for obtaining (by selective mining, crushing, screening, or some other method) loose riprap that will meet the specified material requirements.

PART 3 - EXECUTION

3.1 STABILIZING POOR LOAD BEARING SOILS

- A. Remove all organic material larger than 1 inch in diameter from the Subgrade and grade to elevations required for overlaying backfill.
- B. Compact Subgrade to the extent allowed by the condition of the substrate.
- C. Roll fabric onto Subgrade so Subgrade remains smooth. Do not drag.
- D. Fold or overlap geotextile in direction of drainage.
- E. Provide fabric overlap joints as follows.

Geotextile Overlap		
Soil CBR Rating	Overlap Required	
	Unsewn, inches	Sewn, inches
Less than 1	--	4
1-2	36	4
2-3	30	3
3-5	24	--
Greater than 5	18	--
NOTES (a) Sewn seams, both factory and field seams shall conform to 90 percent of the grab tensile strength requirements.		

- F. Place granular material on top of fabric and spread carefully to insure no puncture. Minimum backfill lift on fabric; 6 inches.
- G. Cover fabric with 6 inches of sand before placing rock larger than 4 inches diameter on top of fabric.
- H. Avoid sudden stops or turning motions by equipment operating on aggregate placed over the fabric.
- I. Compact backfill soils over fabric; Section 33 05 05 to a Standard Proctor Density of 95 percent or greater.
- J. Repair any puncture by covering with new fabric using the same overlap dimensions indicated in



Table above.

3.2 LOOSE RIPRAP

- A. Prior to placement of loose riprap, the granular filter shall be placed and graded to the lines and grades shown on the drawings.
- B. Riprap shall generally be placed starting at the lowest elevations and working upward. Riprap shall be placed to the minimum thickness designated on the drawings and shall be positioned in such a manner that will provide uniform distribution of the various sizes of stone and produce a well-keyed mass of rock with the least practical amount of void space. The surface shall be leveled as necessary, to produce a reasonably uniform appearance and the required thickness.

END OF SECTION



SECTION 32 05 00 RESTORATION OF EXISTING IMPROVEMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Contractor shall provide all materials, labor, equipment, transportation, and other items required to restore existing improvements dislocated, damaged, or removed as indicated or as required to accomplish Work of other sections of these specifications. All restoration Work shall be in accordance with applicable regulations and as specified herein.
- B. Restoration of existing improvements includes, but is not limited to the following:
 - 1. General restoration requirements
 - 2. Restoration or replacement of gravel, asphaltic concrete, or Portland cement concrete pavements, including base course and striping.
 - 3. Portland cement concrete curbs, gutters, sidewalks, and driveways
 - 4. Landscaping improvements
 - 5. Miscellaneous improvements

1.2 RELATED WORK

- A. Section 31 23 16 – Excavation, Backfilling and Compaction

1.3 REFERENCES

- A. The applicable provisions of the latest editions of the References listed below shall govern the Work covered under this Section, unless there is a conflict between said References and the requirements of this Section. In the case of such a conflict, the requirements of this Section shall apply.
- B. Utah Department of Transportation Standard Metric Specifications for Road and Bridge Construction, latest edition including all addenda.
- C. American Society for Testing and Materials (ASTM)
- D. American Association of State Highway and Transportation Officials (AASHTO)
- E. American Concrete Institute (ACI)
- F. Concrete Reinforcing Steel Institute (CRSI)

1.4 SUBMITTALS

- A. Submit shop drawings, manufacturer's literature, certifications, and other product data in accordance with Section 01 00 50, Paragraph 1.5 – Contractor Submittals..
- B. Required submittals include, but are not limited to:
 - 1. Manufacturer's recommended transportation, unloading, and storage requirements as well as installation guides and instructions for materials provided as part of this Work.
 - 2. Evidence of materials conformance with applicable requirements as well as these specifications.
 - 3. Dimensional information for pipes, valves, fittings, castings, structures and other items provided as part of this Work.

- C. Contractor shall maintain accurate construction record drawings for items restored as part of this Work, but covered by subsequent landscaping, paving or as a result of Work of other sections of these specifications. These records shall be submitted to Engineer for approval prior to application for final payment.

1.5 QUALITY ASSURANCE

- A. Transportation, handling, storage and installation practices shall be in accordance with manufacturer's recommended practice for materials provided as part of this Work.
- B. Use adequate numbers of skilled workmen who are trained and experienced in the type of construction required.
- C. The quality of the finished restored improvement, as determined by the Owner, shall be of equal or better quality than was said improvement prior to being damaged or removed.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall be responsible for proper transportation, unloading, handling, storage, and security of all equipment and materials to be provided as part of this specification in accordance with manufacturer's recommendations.
- B. Materials shall be stored in such a manner as to prevent damage or degradation. Any materials damaged prior to installation shall be removed from the project and replaced with new materials at no additional cost. Lost or stolen materials shall be replaced at no additional cost.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers providing materials or equipment as part of this specification shall have a minimum of five years' experience in the design, manufacture, testing and support of such materials.
- B. Manufacturers shall provide, upon request, verification of a consistent record of meeting or exceeding materials or performance standards as specified herein.

2.2 MATERIALS - GENERAL

- A. Materials shall be as required to complete the restoration of existing improvements, and shall be at least equal to original improvement at the time of damage or removal, as determined by the owner of said improvement, and shall match original construction in finish and dimension.
- B. Materials shall be in accordance with requirements of local jurisdiction having authority. Obtain approval of all materials from local jurisdiction having authority prior to ordering.

2.3 BITUMINOUS SURFACE COURSE

- A. Asphaltic concrete surface course shall be plant mix in accordance with UDOT, 1/2" Gradation using PG 64-34 asphaltic cement. Refer to UDOT specifications Section 02741.
- B. Compaction requirements are no tests less than 93.5% percent of the density (determined in accordance with ASTM D2041), as determined by ASTM D2170.

2.4 PORTLAND CEMENT CONCRETE

- A. Portland cement concrete for curbs, gutters, sidewalks and driveways shall be Class AA(AE) conforming to the requirements of Section 0355, UDOT Standard Specification for Road and Bridge Construction.



2.5 SOD AND VEGETATION

- A. All materials shall be from sources approved by the Owner; however, such approval does not relieve the Contractor from responsibilities for growth, maintenance and replacement has specified herein.
- B. Topsoil:
 - 1. Topsoil for backfill mixture for tree pits shall be fertile, friable, natural loam, surface soil, reasonably free of clay lumps, brush, weeds, and other litter, and free of rocks, stumps, stones larger than 2-inch in any dimension, and other extraneous or toxic matter harmful to plant growth. Obtain topsoil only from naturally well drained sites where topsoil occurs in a depth of not less than 4 inch.
 - 2. Do not obtain from bogs or marshes.
- C. Manure:
 - 1. Well dried, rotted, unleached, pulverized cattle manure reasonably free from refuse and harmful materials.
- D. Mulch:
 - 1. Fine grind bark mulch.
- E. Tree staking and guying:
 - 1. Steel T post stakes 8 feet long and steel ground stakes 18 inches long.
 - 2. All T post stakes shall be primed and painted a dark green color.
 - 3. Provide wire ties and guys of 2 strand, twisted, pliable, galvanized iron wire not lighter than 12 gauge.
 - 4. Provide new 2 ply garden hose not less than 5/8 inch diameter in size, cut to required lengths to protect tree trunks from damage by wires.
- F. Sod:
 - 1. Strongly rooted blend of Kentucky Blue Grass sod, not less than 2 years old and free of weeds and undesirable native grasses.
 - 2. Provide only sod capable of growth and development when planted (viable, not dormant).
 - 3. Recommended Kentucky Blue Grass mixture is 50 parts Baron, 25 parts Glade and 25 parts Touchdown, or approved equal.
- G. Commercial fertilizer:
 - 1. Agriform 20 10 5, 21 gram fertilizer tablets for trees and shrubs. Provide three tablets per tree.
 - 2. Ammonium sulfate fertilizer in pellet form for lawn areas at 40 actual pounds of nitrogen per acre.
- H. Trees:
 - 1. Trees shall be not less than indicated sizes, balled and burlapped or container grown, unless otherwise indicated, specified or required by Owner of tree removed.
- I. Shrubs:
 - 1. Shall be as removed, minimum 5 gallon can.



PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that Work covered under other sections of these specifications is complete to the point that Work covered under this section may properly commence without hindering or damaging Work of other trades. Do not proceed with construction until unsatisfactory conditions have been corrected.
- B. Verify that Work performed under other sections of these specifications has been adequately observed, tested and accepted prior to covering up that Work as part of the Work specified under this section.
- C. Carefully examine restoration areas, verifying dimensions, materials and other restoration requirements with Engineer and Owner prior to beginning Work covered under this section.

3.2 METHODS AND PROCEDURES

A. General Requirements

1. Contractor shall obtain all permits necessary for the restoration of existing surface improvements.
2. Contractor shall protect all public and private property adjacent to the work. Exercise due caution to avoid damage to such property.
3. All improvements damaged or removed shall be restored in accordance with local jurisdiction having authority. In case of conflict between these specifications and local authority specifications, the local authority shall govern.
4. Repair or replace all existing surface improvements, which were damaged or removed as a result of operations of Work under this contract. Restoration shall be of at least equal quality and identical in dimension to original improvement unless specifically specified otherwise.

3.3 INSTALLATION

A. Gravel Surfaced Areas

1. Where trenches are excavated through gravel surfaced areas such as roads and driveways and other areas, the gravel surface shall be restored by placing untreated base course material upon a prepared subgrade.
2. Subgrade preparation shall conform to the following:
 - a. Subgrade shall be proof-rolled by passing moderately-loaded rubber tire-mounted construction equipment uniformly over the surface continuously at least twice, or by other means acceptable to Engineer. If excessively soft, loose or disturbed soils are encountered, they shall be removed as directed by Owner, to a maximum depth of two feet, and replaced with stabilizing structural fill, compacted to 96% of the maximum laboratory dry density determined by ASTM D-1557 or AASHTO T-180.
 - b. Place structural fill in lifts not exceeding 8 inches in loose thickness.
3. Base Course
 - a. Thickness of untreated base course surface shall be 6 inches or shall match existing, whichever is greater.
 - b. Base course shall be compacted to no less than 96% maximum Modified Proctor Density, as determined by ASTM D1557 (AASHTO T-180). Moisture content shall be maintained to within 1.5% of optimum throughout placing and compaction operations.



B. Asphaltic Concrete Surfaced Areas

1. Where trenches are excavated through asphaltic concrete surfaced areas such as roads, driveways or parking areas, the surface shall be restored by preparing the subgrade, placing base course, placing tack and prime coats, and placing the asphaltic concrete surface course(s).
2. Subgrade preparation shall conform to applicable parts of Section 02056, UDOT Standard Specifications for Road and Bridge Construction:
 - a. Average of field density determinations shall be 96 percent of the maximum dry density, with no determination lower than 92 percent.
 - b. The maximum dry densities shall be determined in accordance with the following:
 - (i) A-1 Soils: AASHTO Designation T-180, Method D.
 - (ii) All other Soils: AASHTO Designation T-99, Method D.
3. Thickness of base course shall be 6 inches, shall match existing, or shall be as required by local authority having jurisdiction, whichever is greater.
4. Placing and compaction of untreated base course shall conform to applicable parts of Section 02721, UDOT Standard Specifications for Road and Bridge Construction, excluding pay factor allowances.
5. Tack Coat
 - a. Tack coat shall be applied at the rate of 0.05 to 0.15 gal/SY. A hand sprayer or brush shall be used to apply tack coat to vertical faces of previously constructed bituminous pavement (over 1/2 hour hence) prior to placing an adjacent or parallel pass, curbs, gutters, slab edges, and all structures to be in actual contact with the bituminous pavement. Tack coat shall also be applied uniformly at the same rate to the horizontal top surface of each lift of bituminous pavement prior to placing the next lift of bituminous pavement to promote a bond between the two courses of pavement. None of the material shall penetrate into the pavement and for this reason the application should be limited.
 - b. Prior to applying the material, the surface to be treated shall be swept or flushed free of dust or other foreign material.
 - c. Protect all surfaces not required to receive tack coat from any inadvertent application.
 - d. The temperature range of the tack coat at the time of application shall be such that the viscosity will be between 50 and 100 centistokes as determined in accordance with ASTM Designation D2170.
 - e. Under no circumstances shall traffic be permitted to travel over the tacked surface. If detours cannot be provided, restrict operation to a width that will permit at least one way traffic over the remaining portion of the roadbed. If one way traffic is provided, the traffic shall be controlled in accordance with governing authority.
 - f. After application of tack coat, sufficient time shall be given to allow for complete separation of asphalt and water before paving operations begin. The tack coat shall be applied on only as many surfaces as will be paved against in the same day.
6. Mixing, placing, spreading and compaction of bituminous surface course shall conform to applicable parts of Section 02741, UDOT Standard Specifications for Road and Bridge Construction, excluding pay factor allowances.

C. Concrete Curbs, Gutter, Sidewalks and Driveways

1. Shall be removed and replaced to the next joint or scoring lining beyond the actually damaged or broken sections; or in the event that joints or scoring lines do not exist or are three or more feet from the removed or damaged section, the damaged portions shall be removed by saw cutting full-depth.
2. All new concrete shall match, as nearly as possible, the appearance of adjacent concrete improvements. Where necessary, lampblack or other pigments shall be added to the new concrete to obtain the desired results.
3. Concrete forms shall be true to line and of sufficient strength to ensure against bulging or displacement.
4. Contraction and expansion joints shall match original construction in placement and size, unless otherwise required by local jurisdiction having authority.
5. Reinforcement shall be replaced as in original construction, unless otherwise required by local jurisdiction having authority, and shall be installed in accordance with applicable CRSI and ACI Standards.
6. Finishing and curing shall be in accordance with local jurisdiction having authority.

D. Vegetated Areas

1. Prior to placing sod or other final vegetative cover, examine and repair the subgrade as necessary to assure a smooth and even surface which will match grade and contours of surrounding undisturbed ground. Finish grade construction areas to match grade prior to construction activities. Assure that a positive slope away from all building walls is maintained for at least 10 feet to prevent runoff from approaching walls.
2. Prepare soil under areas to receive vegetation by placing topsoil to a depth equal to surrounding conditions or to 6 inches, whichever is greater. Disk or till 3 cubic yards manure per 1000 square feet of surface area to a depth of 8 inches.
3. Roll and rake areas receiving vegetation to smooth, even surface, free of ridges, with loose, uniformly fine texture.
4. Allow for final vegetation thickness when preparing subgrade.
5. Restore raked areas to specified condition if eroded or otherwise disturbed after fine grading and prior to placing vegetative cover.
6. Remove stones over 1 1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter.
7. Limit preparation to areas that will be planted promptly after preparation.
8. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface moisture to dry before sodding. Do not create a muddy soil condition.

E. Trees and shrubs:

1. Layout individual tree locations.
2. Secure approval of Engineer and Owner prior to planting.
3. Excavate tree and shrub pits with vertical sides. Dispose of subsoil removed from landscape excavations. Do not mix with backfill. If tree or shrub is to be planted on excavation area, remove all impervious fill from tree and shrub pit down to pervious material.
4. Place three Agriform fertilizer tablets evenly around the perimeter of, and immediately adjacent to the root ball at a depth which is between the middle and the bottom of the root ball.
5. When excavation is approximately 2/3 full, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing final

layer of backfill.

6. Stake or guy trees immediately after planting. Stakes and guys should be evenly distributed around tree. All stakes must be driven so as not to disturb the root ball.

F. Sprinkling Systems:

1. Restore all sprinkling systems and fences disturbed, removed, or damaged by construction operations in a condition at least equal to that prior to construction.

G. Sodding:

1. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod strips; do not overlap. Stagger strips to offset joints in adjacent courses. Work from boards to avoid damage to subgrade or sod. Tamp or roll lightly to ensure contact with subgrade. Work sifted soil into minor cracks between pieces of sod; remove excess to avoid smothering of adjacent grass.
2. Secure sod on slopes with U-shaped wire clips as required to prevent slippage. Immediately after planting, sod shall be thoroughly watered with a fine spray. Watering shall occur as frequently as needed to keep sod constantly moist for a period of 14 days after planting. Two weeks after planting, apply ammonium sulfate in pellet form at 40 actual pounds of nitrogen per acre. Water thoroughly immediately after fertilizing.

H. Miscellaneous Restoration Items

1. All other improvements interrupted or removed to permit the construction specified herein shall be restored. Miscellaneous improvements to be restored shall include, but shall not be limited to, the following:
 - a. Culverts
 - b. Fences
 - c. Utilities

3.4 PROTECTION

A. Provide barricades and restrict access as appropriate to prevent damage to Work in place.

B. Contractor shall be responsible for protection of Work in place against displacement, damage, loss or theft until Owner's acceptance. Any Work installed and subsequently damaged, lost or displaced shall be repaired or replaced to the Owner's satisfaction at no additional cost.

C. Planting Maintenance:

1. Begin maintenance immediately after planting, and continue until observation and acceptance, in no case less than 30 days from the time of completion of Work.
2. Maintain trees by pruning, cultivation and weeding as required for healthy growth. Restore planting saucers.
3. Tighten and repair stake and guy supports and reset trees to proper grades or vertical position as required. Spray as required to keep trees free of insects and disease.
4. Maintain lawns for not less than 30 days and longer as required to establish an acceptable lawn. To be acceptable, lawn must be past second mowing with no bare spots. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading and replanting as required to establish a smooth, acceptable lawn, free of eroded or bare areas.

3.5 CLEANING

A. Thoroughly clean, rake, wash and/or flush all restoration Work prior to submitting for Owner's



acceptance.

END OF SECTION



SECTION 35 41 00 LEVEE CONSTRUCTION

PART 1 GENERAL

1.1 SCOPE OF WORK

The work covered by this section consists of furnishing all equipment, labor, materials, and incidentals, and performing all operations necessary for the clearing, grubbing, and stripping of the areas specified herein or indicated on the drawings, and for the removal and disposal of cleared, grubbed, and stripped materials, and refilling of holes resulting from grubbing; excavation of borrow areas and existing levees, and for all other required excavations or excavations incidental to the construction of levee embankments and ponding [moat] areas as specified and shown; foundation preparation and the construction of levee embankments, including new levee, enlargement of existing levee, berms, haul roads, road crossings, and other incidental earthwork as may be necessary to complete the levee as specified herein and as shown on the drawings.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 272 (2018) Family of Curves – One-Point Method

ASTM INTERNATIONAL (ASTM)

ASTM D422 (1963; R 2007; E 2014; E 2014) Particle Size Analysis of Soils

ASTM D698 (2012; R2021) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

ASTM D1556/D1556M (2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

ASTM D1557 (2012; R2021) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2700 kN-m/m³)

ASTM D2167 (2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D2216 (2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM D2487 (2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D4318 (2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D6913 (2017) Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis



ASTM D6938 (2021a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D7928 (2021; E2021) Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

1.3 DEFINITIONS

1.3.1 Clearing

Clearing consists of the removal and satisfactory disposal of all [above ground and below ground] trees, downed timber, snags, slash, brush, garbage, trash, debris, fencing, and other items occurring in the designated areas to be cleared.

1.3.2 Grubbing

Grubbing consists of the removal and satisfactory disposal of stumps, roots larger than 1/2 inches in diameter, and matted roots from the designated grubbing areas. Grubbing also includes filling of holes from the grubbing operation.

1.3.3 Stripping

Stripping consists of the removal and satisfactory disposal of crops, weeds, grass, and other vegetative materials to the ground surface and topsoil to a depth of 12 inches.

1.3.4 Satisfactory Materials

Satisfactory materials consist of materials classified in accordance with ASTM D2487 as CL, CL-ML, ML, SC, SM, SP, SW, GC, GM, GP, and GW (and dual classification consisting only of the same), free from: roots and other organic matter; contamination from hazardous, toxic or radiological substances; trash, debris; and frozen materials. Not all satisfactory materials can be used in the levee. Only the satisfactory materials stated above, and also meeting the additional or modified requirements of paragraph TYPES OF FILL MATERIALS, can be used for levee construction.

1.3.5 Unsatisfactory Materials

Do not use unsatisfactory materials in any levee or other required fill. Unsatisfactory materials include all other materials that are not defined above as satisfactory materials. Materials which do not comply with the requirements for satisfactory materials are unsatisfactory.

Unsatisfactory materials also include man-made fills (unless excavated, sorted / separated / stockpiled, and tested); trash; refuse; backfills from previous construction; concrete/asphalt, and material classified as satisfactory which contains root and other organic matter or frozen material.

1.3.6 Embankment

The term "embankment" as used in these specifications is defined as the earth fill portions of the levee structure or other fills related to the levee structure, and also includes all types of earth fill and all other fills within the limits of the levee as shown on the project drawings. Stone and other rock materials (riprap) used for slope protection/armoring is described in a different Section.

1.3.7 Excavation

Excavation consists of removal of material and existing levees to the lines and grades shown on the



drawings, or as otherwise directed or approved by the Engineer.

1.3.7.1 Over-excavation

Excavation performed beyond lines and grades shown on the plans that is made at the convenience of contractor. No separate payment will be made for over-excavation or for additional embankment materials needed to backfill the over-excavation.

1.3.7.2 Additional Excavation

Excavation performed beyond lines and grades shown on the plans that is performed at the direction of the Owner, and to be paid at unit prices for excavation and backfill, or as negotiated.

1.3.8 Classification of Soils

Materials used to construct the embankments and for backfills will be classified in accordance with ASTM D2487 (Unified Soil Classification System). Cohesionless materials include materials classified as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, CL-ML, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic.

1.3.9 Degree of Compaction

1.3.9.1 Cohesionless Material

Relative Compaction (or Degree of Compaction) is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D698, abbreviated hereinafter as percent laboratory maximum density.

1.4 SUBMITTALS

1.4.1 Preconstruction Submittals

1.4.1.1 Plan of Operations (Work Plan)

Submit for approval complete and detailed descriptions of proposed earthwork plan. This plan must include, but not be limited to, the Contractor's proposed sequence of construction for all earthwork including backfill and embankment items; methods and types of equipment to be utilized for all earthwork operations, including transporting, placing and compacting; quantity, type and final disposition of stockpiled materials; location and drainage of proposed stockpiles; proposed disposition of all excavated materials, including items which are anticipated to be disposed of off-site. Submit the earthwork plan to the Owner not less than 30 days prior to initiating any earthwork operation unless otherwise approved by the Engineer.

Work plan should address levels of flood protection provided during levee construction and the measures to be taken by Contractor to provide levels of protection acceptable to Owner.

1.4.1.2 Embankment and Backfill Materials

At least 30 days prior to delivery of any Contractor-furnished or Contractor-processed material to the site of the work, submit for approval soil classification test results, moisture-density curves, gradation curves, and laboratory results of the required tests of the proposed material.

1.4.1.3 Excavation Plan

Submit complete and detailed descriptions of proposed excavation plan. Obtain approval of the detailed plan from the Engineer prior to starting the work. If necessary, modify the plan as required to meet field



conditions, and the modifications must be approved prior to use. This plan must include:

- a. Proposed methods for preventing interference with, or damage to, existing underground or overhead utility lines, trees designated to remain and other man-made facilities or natural features designated to remain within or adjacent to the construction rights-of-way.
- b. Provision for coordinating the work with other Contractors working in the construction rights-of-way or on facilities crossing or adjacent to this work.
- c. The proposed methods for controlling surface and ground water in the borrow areas and required excavations. Surface water must be directed away from excavations and construction sites so as to prevent erosion and undermining of improvements or permanent work.
- d. Stockpiling plan for embankment material before it is transported to the project site showing locations, stockpile heights, slopes, limits, and drainage around the stockpile areas.
- e. A complete listing of equipment used for excavation and to transport the excavated material.
- f. The proposed sequence of work for excavating the borrow areas with plan and cross section views showing starting and final work locations and clearing, grubbing and stripping limits.
- g. Proposed haul road and haulage patterns, and plan for implementing dust control measures. Plan must address any phased construction, interfaces with public traffic, and airport operational needs. Any haul road which crosses any ditch, culvert, creek, river, or drainage channel must be constructed and maintained so as to not flood either upstream areas by restricting stream flows or flood downstream areas by the release of any stored water in the event that the crossing fails for any cause. Haul roads constructed during the contract duration to be removed after work is completed and the impacted area restored to its preconstruction conditions. All haul roads within the right-of-way that will remain as public thoroughfares after construction must be cleaned daily and maintained in the preconstruction condition.
- h. Proposed disposition of all excavated materials, including items which are anticipated to be disposed of off-site.

1.4.2 Shop Drawings and Product Data

Submit for approval complete and detailed shop drawings and product data for the following items (as applicable), demonstrating compliance with these specifications and standard construction practices. Engineered designs must be signed and sealed by Professional Engineer licensed in the state of Utah.

- a. Shoring Design
- b. Dewatering Design
- c. Borrow Areas

Submit to the Engineer the source or sources intended to provide materials for embankment construction. If a source is selected other than a commercial quarry or other commercial entity from which earth or rock material will be directly purchased and where the Contractor or his subcontractor will perform the borrow excavation, a written statement will be provided to the Engineer indicating permission to utilize the area. It is the Contractor's responsibility to obtain Federal, State, and local permits which may be required for excavation and reclamation of the borrow area. Contractor is solely responsible for securing material of sufficient quantity and quality to complete the work.



1.4.3 Soil Material and Placement Tests, including in-place density (compaction) Tests

Submit test results for all testing specified as part of Quality Control work in Paragraph 3.21. Submit results within one day of obtaining result. Compaction test results should be accompanied by the applicable moisture-density curve.

1.5 PROJECT SITE CONDITIONS

1.5.1 Historical, Archeological, and Cultural Resources

Historical, archeological, and cultural resources within the Contractor's work limits may exist. If, during construction activities, the Contractor observes items that may have historical or archeological value, such observations will be reported immediately to the Engineer so that appropriate authorities may be notified and a determination made as to their significance and what, if any, special disposition of the finds should be made. Cease all activities that may result in the destruction of these resources and prevent the workers from trespassing on or otherwise damaging such resources.

1.5.2 Subsurface Data

Subsurface soil boring logs are provided in Project Documents as "For Information Only." Additional subsurface study reports and samples of materials may be available from the Owner. These data represent subsurface information at the study locations; however, variations may exist in the subsurface between study locations. Groundwater levels indicated on logs were levels found at the time of study. Groundwater conditions can vary significantly depending on time of year in response to precipitation, and stages in rivers or other bodies of water, lake, or tide levels. The Contractor is ultimately responsible for subsurface interpretation across the entire project site.

PART 2 PRODUCTS

2.1 TYPES OF FILL MATERIALS

2.1.1 Levee Embankment Fill

Satisfactory Material with the following properties:

SIEVE SIZE (U.S. STANDARD SQUARE MESH)	PERCENTAGE (BY WEIGHT) PASSING INDIVIDUAL SIEVE
3-inch	100
3/4-inch	70 to 100
No. 4	55 to 80
No. 40	35 to 60
No. 200	25 to 40

Levee Embankment Fill must also have a liquid limit (LL) of 40 or less, and a Plasticity Index (PI) between 6 and 28 (inclusive), as determined by ASTM D4318.

Materials obtained from required excavation which meet, or which can be processed to meet, the requirements for Levee Embankment Fill material may be utilized as such. Submit to the Engineer the source or sources intended to provide materials for embankment construction, together with test results needed for soil classification, Atterberg limit tests, moisture-density curves, gradation curves, and other laboratory test results needed to assess suitability of the material.

2.3 MANUFACTURED PRODUCTS

2.3.1 NOT USED.



PART 3 EXECUTION

3.1 CONSTRUCTION

3.1.1 Lines and Grades

Construct embankment and backfill to the lines, grades, and cross sections indicated on the drawings, unless otherwise directed by the Engineer. The Engineer reserves the right to increase or decrease the foundation widths and embankment slopes or to make such other changes in the embankment or backfill sections as may be deemed necessary to produce a safe structure. Changes in quantities resulting from such revisions will not constitute justification for change in contract unit prices. Provide end slopes and side slopes of partial fill sections no steeper than one vertical on two-and-one-half horizontal, unless otherwise shown on the drawings.

3.1.2 Conduct of the Work

Maintain and protect the embankment and backfill in a satisfactory condition at all times until final completion and acceptance of all work under the Contract. If, in the opinion of the Engineer, the hauling equipment causes horizontal shear planes or slicken sides, rutting, quaking, heaving, cracking, or excessive deformation of the embankment or backfill, limit the type, load, or travel speed of the hauling equipment on the embankment or backfill. The Contractor may be required to remove, at no additional payment, any embankment material placed outside of prescribed slope lines. Replace approved embankment or backfill material which is lost in transit or rendered unsuitable after being placed in the embankment or backfill and before final acceptance of the work in a satisfactory manner and no additional payment will be made therefore.

Excavate and remove from the embankment or backfill any material which is unsatisfactory, dispose of such material, and refill the excavated area as directed by the Engineer, all at no cost to the Owner.

Locate and construct haul roads, ramps, and crossings as indicated on the drawings or as approved by the Engineer. Prior to the commencement of construction, submit for approval a site plan detailing the location of all haul roads within the project limits. Areas beyond the borrow haul road corridor must not be disturbed. Construct haul roads to maintain the intended traffic, be free draining, and remain in good condition throughout the contract period. Any haul road which crosses any creek or drainage channel must be constructed and maintained so as to not flood either upstream areas by restricting stream flows or flood downstream areas by the release of any stored water in the event that the crossing fails for any cause. Remove haul roads constructed during the contract duration after work is completed and the impacted area restored to its preconstruction conditions. All haul roads within the right-of-way that will remain as public thoroughfares after construction must be cleaned daily and maintained in the preconstruction condition. Consider all costs associated with these haul roads as a subsidiary obligation of the Contractor.

Do not block or restrict the flow in a natural drain, existing culvert, ditch or channel at any time without obtaining prior written approval from the Engineer. This approval will not relieve the Contractor from responsibility for any damage caused by the operation. Monitor the water flow and provide sufficient free discharge areas so that conditions are not worsened upstream or downstream by possible floods during construction. Surface water will be directed away from excavations and construction sites so as to prevent erosion and undermining of levee foundations. Diversion ditches, dikes, and grading will be provided and maintained as necessary during construction. Protect excavated slopes and backfill surfaces to prevent erosion and sloughing. Perform excavation so that the site and the area immediately surrounding the site and affecting operations at the site will be continually and effectively drained and critical infrastructure protected from changes in lake elevation.

Unless indicated otherwise and directed by Engineer, do not work beyond the lakeside toe of the existing levee.



3.2 CLEARING

Accomplish clearing within the limits shown on the drawings of existing ground to receive levee embankment. Clear trees, brush, garbage, trash, debris, fencing and other items flush with the existing ground surface. Protect trees and vegetation designated to be left standing or to remain from damage from construction operations. Limit clearing of borrow areas to the minimum area required for construction operations.

3.3 GRUBBING

Accomplish grubbing within the limits shown on the drawings of existing ground to receive embankment. Accomplish grubbing to a depth of at least 3 feet below the existing ground surface. Fill holes caused by grubbing operations and removal of pipes and drains, excluding holes in borrow areas, channels and ditches above required grade, with satisfactory materials. Place material in 6 inch layers to the elevation of the adjacent ground surface and each layer compacted to a density at least equal to that of the adjoining undisturbed material.

3.4 STRIPPING

The entire area within the limits shown on the drawings should be stripped to remove crops, weeds, grass, and other vegetative materials to the ground surface and topsoil to a depth of 12 inches.

3.5 DISPOSITION OF CLEARED, GRUBBED, AND STRIPPED MATERIAL

Except as otherwise specified or indicated on the drawings or by the Engineer, dispose all materials resulting from clearing and grubbing operations offsite. The Contractor may opt either to retain any such materials of value or dispose of them by sale or otherwise. The Owner is not responsible for the protection and safekeeping of any materials retained by the Contractor. Do not leave such materials windrowed or stockpiled within construction limits after completion of project. Do not bury or burn such materials.

3.6 REMOVAL OR PLUGGING OF ABANDONED PIPE AND CONDUITS

Remove abandoned pipes and conduits to the limits shown on the drawings or abandon in place by grouting or filling with concrete as shown on the plans. Prior to plugging, clean the interior of the pipe to be plugged and place the concrete in such a manner as to provide a dense, well bonded plug.

3.7 SHORING, SHEETING, AND BRACING

Submit a detailed shoring, sheeting and bracing plan as specified in Paragraph 1.4. Shoring must be designed so that it is effective to the bottom of the excavation, and must be based upon calculation of pressures exerted by the earthen materials to be retained, including the condition and nature of those materials as well as any surcharge loads imparted to the excavation by slopes, equipment, traffic, or stored materials. Include in the plan drawings and design computations of the proposed shoring, sheeting, and bracing, and documentation, showing details of the coordination and approval of shoring, sheeting, and bracing by the applicable parties. Obtain approval of the detailed plan from the Engineer prior to starting the work. If necessary, modify the plan as required to meet field conditions, and the modifications must be approved prior to use.

Install shoring, sheeting, and bracing where required for the protection of existing natural features and man-made facilities, for the safety of workers and the public, and to protect the integrity of the embankment. Design, furnish and install sheet piling, cribbing, bulkheads, bracing, shores or whatever means that may be necessary to support earthen material carrying structures and other improvements, and maintain such piling, cribbing, bulkheads, bracing, shores in position until they are no longer needed. Do not use shoring, sheeting and bracing in lieu of the required excavation slopes. Design and properly install shoring, sheeting, and bracing to withstand anticipated loads. Remove all shoring, sheeting and bracing as embankment and backfill operations progress so that the backfill is placed directly against the

undisturbed excavation face. Shoring deemed necessary by the Engineer must remain in place during the backfill operations. Remove shoring in such a manner as not to disturb or damage the completed work or any adjacent property. If any problems are encountered during excavation, stop excavation operation and notify the Engineer.

3.8 DEWATERING AND DIVERSION

Accomplish surface and groundwater control in coordination with the required excavation and embankment construction. Surface and/or groundwater control may necessitate the use of temporary diversion ditches, cofferdams and/or dewatering by the use of pumping. Methods for care of surface water and for controlling the surface and groundwater levels will be subject to approval of the Engineer. Borrow pits must be drained and kept dry during excavation, as excavation will not be permitted in water nor will excavated material be scraped, dragged or otherwise moved through water. Drain borrow and excavation areas by ditching, sump pumping, or other approved methods. Drain borrow and excavation areas addressed under this contract and flooded from rains, high river, and lake stages and allow to dry as quickly as practicable after the high water has passed.

Minimize surface runoff from entering the work areas. Complete the necessary ditching or earthwork shaping at the end of each workday or as necessary to prevent surface runoff from entering the work area. Drain excess precipitation that collects in the work areas and allow to dry as quickly as practicable before work resumes.

3.9 EXCAVATION

Excavation will consist of removal of material in preparing the base of the levee and any foundations to the lines and grades shown on the drawings, removal of material from ditches and channels to the lines and grades shown on the drawings, removal of objectionable materials and obtaining required fill materials from the borrow areas. Over excavation will be backfilled to grade with satisfactory levee embankment material and compacted to a density of at least that of the surrounding material. Backfill and compact excavation beyond the lines shown on the plans in accordance with adjacent materials as directed.

3.9.1 Slopes and Surcharges

Temporary excavation slopes for any excavation must not be steeper than the specified finished slope or the specified construction slope. Any field deviations from this provision must be approved by the Engineer. Temporary slopes must be benched such that the average slope is not steeper than the specified slope. In addition, do not surcharge temporary, permanent, or construction slope with excavated or stockpiled material or with heavy construction equipment which would have the same effect as the surcharge material. Maintain the toe of stockpiled material a minimum distance back from the top of the finished excavation equal to the depth of the excavation. Determine the maximum height of such stockpile without causing instability of the excavation slope and provide justification for such in the Excavation Plan submittal.

3.9.2 Borrow Areas

3.9.2.1 Owner-Furnished

Excavate borrow areas to the extent necessary to obtain satisfactory material within the lines and grades as shown on the drawings. When the material necessary for the construction of the embankment and berms cannot be obtained from adjacent borrow areas, obtain it from other Owner-furnished borrow areas. Permissible depth(s) in the borrow areas are indicated on the drawings. Backfill any excavation below the depths and slopes specified herein or shown on the drawings, at the Contractor's expense, to the specified permissible excavation line, with satisfactory materials as specified by the Engineer to a condition and density of at least that of the surrounding material. Drain borrow areas and keep dry during excavation. In so far as is practicable, do not remove unsatisfactory materials in borrow areas unless otherwise directed by the Engineer.



3.9.2.2 Contractor-Furnished

Proposed borrow areas will be subject to approval by the Engineer. Any borrow sources proposed, accepted and approved by the Engineer must meet all applicable Federal, State and local requirements including written evidence to the Engineer that the Contractor has obtained property rights and access to the material therein. No payment will be made for acquiring or utilizing Contractor-furnished borrow areas other than the unit cost of the material provided.

3.9.3 Existing Levees and Spoil Banks

Remove existing levees and spoil banks as shown on the drawings. For this project, the intent is to remove and replace the existing levee with new levee. Provide flood protection while existing or new levee section is not present. When excavated for borrow material, remove the existing levee to the adjacent ground surface, or the elevation shown on the drawings if deeper, in a uniform manner, and shape to maintain drainage in accordance with the adjacent natural drainage pattern.

3.10 TOLERANCES

Construct all embankments and backfills to the grades, lines, and cross-sections shown on the drawings. A tolerance of 2 inches above or below the prescribed grade will be permitted in the final dressing of slopes. Grade crown (crest) of levee with a tolerance of 0 to 0.3 feet above and 0 feet below elevation grades shown in project plans. Distribute any excess material so that the crown of the levee drains and that there are no abrupt humps or depressions in any surfaces

3.11 SLIDES AND SLOPE / FOUNDATION FAILURES

In case sliding or slope failure occurs in any part of the excavations, embankments (levee or otherwise), or backfills prescribed in this section after they have been excavated or placed, but prior to final acceptance of all work under the contract, repair as directed by the Engineer. Repairs could include cutting out and removing the slide or failure from an embankment and then rebuilding that portion of the embankment, or constructing a stability berm. In case the slide or slope failure is caused through the fault or negligence of the Contractor, repair at no cost to the Owner.

3.12 STOCKPILES

Provisions of paragraph SLOPES AND SURCHARGES are applicable to all stockpiled materials. Upon completion of construction operations, remove and dispose of all remaining stockpiled material by the disposal methods specified in paragraph DISPOSITION OF EXCAVATED MATERIALS.

3.13 SURFACE DRAINAGE OF COMPLETED AREAS

Grade the areas shown on the drawings designated as GRADE FOR SURFACE DRAINAGE, the borrow areas, and the finished embankment areas to the lines and grades shown on the drawings. Provide surface that is free from sharp ridges, gullies, potholes, sinkholes, and any other surface irregularities. A tolerance of 2 inches above or below the prescribed grade will be allowed provided that the surface drains in the direction as indicated on the drawings.

3.14 MAINTENANCE OF WORK

3.14.1 Debris Removal

Maintain all ditch, channel, and pond (moat) excavations free from leaves, brush, sticks, trash, and other debris until final acceptance of all work under the contract at no additional cost to the Owner.

3.14.2 Sediment Removal



Prior to final acceptance of all work under this contract, remove sediments from ditch, channel, or pond (moat) excavations to restore design grade and section at no additional cost to the Owner.

3.15 DISPOSITION OF EXCAVATED MATERIALS

3.15.1 Satisfactory Materials

Incorporate satisfactory excavated material in the appropriate zones of the levee embankment. When direct placement is not practicable, satisfactory material from the excavation may be stockpiled for subsequent use in parts of the work for which it is specified herein and/or as indicated on the drawings. Dispose satisfactory materials in excess of the quantity necessary to construct backfills and embankments as specified for unsatisfactory materials.

3.15.2 Unsatisfactory Materials

Permanently dispose unsatisfactory materials from the excavations prescribed in this section by removal from the site to a Contractor-furnished disposal area or by placing in any disposal area shown on the drawings. Shape the material so that its surface is free from abrupt changes in grade and slope to drain. No additional payment will be made for contractor-furnished disposal areas or placement in abandoned portions of the borrow areas.

3.16 PREPARATION OF FOUNDATION SOILS (BASE OF LEVEE), PARTIAL FILL SURFACES AND ABUTMENTS

After excavation (as described in paragraph EXCAVATION) or stripping (as described in paragraph CLEARING, GRUBBING AND STRIPPING) of the embankment foundation and any excavation related to the levee to the extent indicated or otherwise required, break down the sides of stump holes, test pits, and other similar cavities or depressions to flatten out the slopes, and scarify the sides of the cut or hole to provide bond between the foundation material and the fill. Do not proceed with fill placement until Engineer has observed the prepared foundation. Scarify the slopes and bottom of the levee as directed. Perform all scarifying and breaking of ground surface parallel to the centerline of the levee. Unless otherwise directed, fill each depression with the same material type that is to be placed immediately above the foundation. Place the fill in layers, moistened, and compacted in accordance with the applicable provisions of paragraphs PLACEMENT, MOISTURE CONTROL, and COMPACTION for the specific material type. Compact materials which cannot be compacted by roller equipment because of inadequate clearances with power tampers in accordance with the paragraph COMPACTION for the specific material type.

After filling of depressions and immediately prior to placement of compacted fill in any section of the embankment, thoroughly loosen the foundation of such section by scarifying, plowing, discing or harrowing to a minimum depth of 6 inches, and adjust the moisture content to the amount specified in paragraph MOISTURE CONTROL for the appropriate type of material. Immediately prior to placement of compacted fill on or against the surfaces of any partial fill section, remove all soft or loose material, all material containing cracks or gullies, and all material that does not conform with the specified zoning of the embankment. Loosen the remaining surface of the partial fill by scarifying, plowing, discing or harrowing to a minimum depth of 6 inches, and adjust the moisture content as specified in paragraph MOISTURE CONTROL for the appropriate type of material. Compact the surface of the partial fill section upon which fill is to be placed as specified for the appropriate type of fill. No separate payment will be made for loosening and rolling the foundation area, the abutment area, or the surfaces of partial fill sections, but the entire cost thereof will be included in the applicable contract price for fill.

3.16.1 Benching

Benching into existing levee embankment and abutments is required in order to place and compact the material in horizontal layers. The vertical face cut into the existing embankment or abutment resulting from the benching operation must be a minimum of 12 inches in height but cannot exceed 48 inches in height. The resulting equivalent slope of the bench must be approximately 1H:1V of flatter, and maintain

adequate stability. Maintain a minimum 8-foot clearance between existing and new materials at the top of each bench; this may necessitate cutting upper benches wider (further into the existing slope) than lower benches.

3.17 TEST FILL STRIP(S)

3.17.1 General

Before beginning embankment construction, construct test strip(s) for levee embankment materials to demonstrate that the equipment and compaction procedure will achieve the moisture density relationship as specified. The test strips may be incorporated as part of the final embankment, if the fills meet the requirements of the specifications. Each test strip shall be of sufficient size to allow compaction equipment to achieve normal operating speed over a 50-foot length. The test strip must be a minimum of three (3) times wider than the compaction equipment. Construct each test strip with a minimum of 4 lifts. Prior to the construction of the test strips, prepare the foundation (subgrade) soils per this specification. Construct the test strips in accordance with the applicable provisions of paragraphs PLACEMENT, MOISTURE CONTROL, and COMPACTION for the specific material type. Place and spread the fill material in layers in accordance with the applicable provisions of paragraphs PLACEMENT AND SPREADING for the specific material type. If the use of the proposed compaction equipment causes shearing of the fill, laminations in the fill, or results in inadequate compaction, the Engineer may direct that such equipment be removed from the fill and that other equipment be used.

3.17.2 Testing and Reporting Requirements for Test Strips

Prior to construction of the test strips, perform laboratory compaction test[s] for each type of material used in test strips. Perform compaction tests in accordance with the requirements specified in paragraph MATERIALS TESTING. Submit test results to the Engineer before construction of the test strips. After placement and spreading of the fill in the test strip, but prior to compaction, obtain five samples from each lift for moisture content determination in accordance with ASTM D2216. Use nuclear density testing equipment in accordance with ASTM D6938. In addition, the following condition applies: .

- a. Prior to using the nuclear density testing equipment on the site, submit to the Engineer a certification that the operator has completed a training course approved by the nuclear density testing equipment manufacturer, the most recent data sheet from the manufacturer's calibration, and a copy of the most recent statistical check of the standard count precision.
- b. Provide nuclear density testing equipment capable of extending a probe a minimum of 12 inches down into a hole.]

After compaction of the fill, perform a minimum of 5 in-place nuclear density and moisture content tests (in accordance with ASTM D6938) and one (1) sand cone density test (in accordance with ASTM D1556/D1556M) on each lift. Obtain one sample from each test strip for classification testing as specified in paragraph MATERIALS TESTING. All testing and sampling locations will be determined by the Engineer. The Contractor's QC personnel will monitor and document construction and testing of the test strips. Documentation must include weather conditions, soil type, spreading and compaction equipment type, lift thickness, number of coverages, moisture content, dry density, and a plan showing approximate location of sampling and testing. Provide documentation of the test strip construction procedures and results of all testing to the Engineer. Do not commence full scale embankment construction until the equipment and placement methods are approved by the Engineer.

3.18 PLACEMENT AND SPREADING

3.18.1 General

Prior to beginning embankment placement on the levee foundation, notify the Engineer that the foundation is ready to receive fill. Do not place fill on any part of the embankment foundation until such areas have been observed/evaluated and no exceptions (documented in writing) have been taken by

the Engineer.

Place and compact levee fill material in horizontal lifts. Place and compact levee fill material such that compacted lifts extend beyond the neat line for the embankment, thereby overbuilding the section before finish grading. Obtain finished grading by cutting excess embankment material.

3.18.1.1 Gradation and Distribution

The gradation and distribution of materials throughout each zone of the levee must be such that the embankment will be free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from surrounding material of the same class. If lenses, pockets, or layers of materials differing substantially in texture or gradation from surrounding material occur in the spread material, mix the layer by harrowing or any other approved method to blend the materials. During the placing and spreading process, maintain at all times a force of workers adequate to remove all roots, debris, and oversize stone from all embankment materials. Avoid segregation. Remove all stones and rock fragments that are either: a) larger than 1/2 of the placement lift thickness, measured by the greatest dimension or b) larger than 3 inches in any dimension, at the source prior to hauling to the fill. Do not place fill upon a frozen surface, nor incorporate snow, ice, or frozen earth in the embankment.

3.18.1.2 Foundations and Partial Embankment Fills

Keep the foundations and all partial embankment receiving fills thoroughly drained. Placing operations will be such as to avoid mixing of materials from adjacent sections as much as practicable.

3.18.1.3 Equipment Traffic

Route equipment traffic on any embankment zone to distribute the compactive effort as much as practicable. Ruts formed in the surface of any layer of spread material will be filled before that material is compacted. If, in the opinion of the Engineer, the compacted surface of any layer of material is too smooth to bond properly with the succeeding layer, loosen the surface by scarifying or other approved methods before material from the succeeding layer is placed.

3.18.2 Placement on Surfaces Containing Frozen Materials

Do not place embankment on a foundation which contains frozen material or which has been subjected to freeze-thaw action. This prohibition encompasses all foundation types, including the natural ground, all prepared subgrades (whether in an excavation or on an embankment, and all layers of previously placed and compacted earth fill which become the foundations for successive layers of earth fill). Remove all material that freezes or has been subjected to freeze-thaw action during the construction work, or during periods of temporary shutdowns, such as, but not limited to nights, holidays, weekends, or winter shutdowns of earthwork operations, to a depth that is acceptable to the Engineer and replace with new material. Alternatively, thaw, dry, rework and recompact the material to the specified criteria before placing additional material. The Engineer will determine when placement of fill must cease due to cold weather. The Engineer may elect to use average daily air temperatures, and/or physical observation of the soils for the determination. Levee embankment material must not contain frozen clumps of soil, snow or ice.

3.18.3 Placement of Embankment and Backfill Against Structures

Do not place embankment or backfill on or against concrete less than 7 days after placement or 70 percent of the design strength, without prior approval of the Engineer. Accomplish compaction within 3 feet of completed or partially completed structures by the use of mechanical hand tampers, vibrating plates, or other approved methods and equipment. Ensure that compaction operations do not damage any existing utilities. Any damage caused by the Contractor's operation must be repaired at the Contractor's expense.

3.18.4 Levee Embankment Fill

Place and spread Levee Embankment Fill material in layers not more than 8 inches in uncompacted thickness, unless results from Test Fill Strips indicate a greater thickness can be used. Layers should be started to the full extent of the embankment side slopes and associated staking. Layers must be carried substantially horizontal and parallel to the levee centerline with sufficient crown or slope to provide satisfactory drainage during construction.

3.19 MOISTURE CONTROL

3.19.1 General

The materials in each layer of fill must contain the amount of moisture, within the limits specified below or as directed by the Engineer, necessary to obtain the required compaction. Rework material that is not within the specified moisture content limits after compaction to obtain the specified moisture content, regardless of density.

3.19.1.1 Insufficient Moisture for Suitable Bond

If the top or contact surfaces of a partial fill section become too dry to permit suitable bond between these surfaces and the additional fill to be placed thereon, loosen the dried materials by scarifying or discing to such depths as may be directed by the Engineer, dampen the loosened material to an acceptable moisture content, and compact this layer in accordance with the applicable requirements of paragraph COMPACTION.

3.19.1.2 Excessive Moisture for Suitable Bond

If the top or contact surfaces of a partial fill section become too wet to permit suitable bond between these surfaces and the additional fill to be placed thereon, scarify and dry the wet material, assisted by discing or harrowing, if necessary, to such depths as may be directed by the Engineer. Dry the material to an acceptable moisture content, and compact in accordance with the applicable requirements of paragraph COMPACTION.

3.19.1.3 Drying Wet Material

Material that is too wet must be dried prior to bringing to the levee embankment. Drying may be assisted by discing, harrowing, or heating, if necessary, until the moisture content is reduced to an amount within the specified limits.

3.19.1.4 Increasing Moisture in Dry Material

The moisture content of material that is too dry will be adjusted prior to bringing to the lead edge of levee embankment. Add water to the fill material and by harrowing, or other approved methods, work the moisture into the material until a uniform distribution of moisture within the specified limits is obtained. Control the amount of water applied on a layer of fill on the levee embankment so that free water will not appear on the surface during or subsequent to rolling. Should too much water be added to any part of the embankment, delay the rolling on that section of the embankment until the moisture content of the materials is reduced to an amount within the specified limits. If it is impracticable to obtain the specified moisture content by wetting or drying the material on the fill, the Contractor may be required to pre-wet or dry back the material at the source of excavation or in the borrow area.

3.19.2 Levee Embankment Fill

The moisture content after compaction must be within the limits of 3 percent above optimum to 1 percent below optimum moisture content as determined by ASTM D698.



3.20 COMPACTION

3.20.1 Compaction Equipment

Provide suitable soil placement and compaction equipment to achieve at least minimum specified degree of compaction within specified range of moisture content. Equipment shall be evaluated through one or more test fills that are constructed under representative working conditions (see TEST STRIP FILLS).

3.20.2 Compaction of Levee Embankment Fill

After a layer of material has been dumped and spread, break up clumps/clods and blend the fill materials to obtain uniform moisture distribution. When the moisture content and the condition of the layer are satisfactory, compact the lift to a minimum of 95 percent of the maximum dry density as determined by ASTM D698. In areas which are not accessible by roller or large equipment, place the fill in layers not more than 4 inches in uncompacted depth and compact with an approved hand operated compactor to a density equal to that obtained in other areas. Dumping, spreading, sprinkling, and compacting may be performed at the same time at different points along a section when there is sufficient area to permit these operations to proceed simultaneously. Operate compaction equipment such that the strip being traversed overlaps the rolled adjacent strip by not less than 3 feet.

3.21 FIELD QUALITY CONTROL

3.21.1 Clearing, Grubbing, and Stripping

Establish and maintain quality control records for clearing, grubbing, and stripping operations to assure compliance with contract requirements, and maintain records of the quality control for all construction operations including but not limited to the items indicated below. Furnish these records, as well as the records of corrective actions taken, to the Engineer.

3.21.1.1 Clearing

Station to station limits, transverse clearing limits from applicable centerline; percentage of area complete; types of materials cleared.

3.21.1.2 Grubbing

Station to station limits, transverse grubbing limits from applicable centerline; percentage of area complete; type of material; filling of grubbed holes.

3.21.1.3 Stripping

Station to station limits, transverse stripping limits from applicable centerline; percentage of area complete; type of material; depth of stripping.

3.21.2 Excavation

Establish and maintain quality control for excavation operations to assure compliance with contract requirements, and maintain records of the Contractor's quality control for all construction operations including but not limited to the following:

- a. Equipment; type, size, suitability for the work,
- b. Lines, grades and tolerances,
- c. Segregation and disposition of materials,
- d. Disposal and/or stockpiling of materials,
- e. Unsatisfactory materials,
- f. Conditions that may induce seepage or weaken the foundation or embankment,



- g. Stability of excavations,
- h. Quantity surveys.

Furnish records of inspections and tests, as well as the records of corrective actions taken, to the Engineer.

3.21.3 Embankment

3.21.3.1 General

As a part of the Contractor Quality Control (CQC) process, establish and maintain field quality controls for preparation of soil foundation for the levee embankment, and for operations relative to embankment and backfill construction to assure compliance with contract requirements. Maintain records of field quality control for all aspects of operations, including but not limited to the following:

- a. Type, size, number of units and suitability of earthwork equipment for construction of the prescribed work.
- b. Methods of preparing the foundations in advance of embankment and backfill construction and methods for providing drainage of the foundation and partially completed fills.
- c. Layout, maintaining existing drainage, moisture control, thickness of layers, spreading and compacting.
- d. Crown width, crown slope, side slopes, and grades.
- e. Location of temporary roads to fields or buildings, location and placement of fills for ramps in accordance with specified dimensions and grades.
- f. Checking fills to determine if placement conforms to prescribed grade and cross section.
- g. Location and limits; methods and equipment used where remedial work has been directed.
- h. Surveying to evaluate quantities.

3.21.3.2 Materials Testing

Perform sufficient testing to ensure that all fill is being constructed as specified. Consider the testing program specified below the minimum acceptable frequency of testing. This does not relieve the Contractor from the responsibility of performing additional testing as needed to ensure that all earthwork complies with these specifications.

3.21.3.2.1 Test for Soil Classification

Perform soil classification tests in accordance with ASTM D2487. Perform one initial classification test for each different classification of material to be utilized as levee embankment fill or backfill. As prescribed in ASTM D2487, perform grain size analyses in accordance with ASTM D6913 and D7928 and Atterberg limits in accordance with ASTM D4318 on each different classification. Submit additional tests for every 2,000 cubic yards of levee embankment or backfill material. Perform soil classification tests on foundation material as required to determine the acceptability of the in-situ soils. Additional tests will be required if noticeable changes in the material occur.

3.21.3.2.2 Cohesionless Material Testing

3.21.3.2.2.1 Moisture-Density Relationships ("Proctor" Tests for Evaluating Maximum Dry Unit Weight)



Determine the moisture-density relations for each different classification of cohesionless material utilized in accordance with ASTM D698. Prior to placing any fill material, perform a minimum of 3 five-point compaction test on representative samples of the material to be used as fill. During fill placement perform a minimum of one additional moisture-density test for every 5,000 cubic yards placed. Additional tests will be required each time a new material is encountered or used. The moisture-density curves will be compiled to form a family of curves (AASHTO T 272) which will be utilized to estimate optimum properties (maximum dry density and optimum moisture content) to be used with field density test.

3.21.3.2.3.3 In-Place Density Testing (Compaction Tests) for Cohesionless Soils

Determine the in-place density of the cohesive materials in accordance with ASTM D1556/D1556M, ASTM D2167, or ASTM D6938. Perform at least one (1) in-place density test on each lift of material per shift or every 500 cubic yards of completed fill, whichever is more frequent, with the horizontal locations randomly staggered in the fill. Retest fill not meeting the required specifications for in-place density after additional compaction has been completed. When nuclear method is used for in-place density testing according to ASTM D6938, include a sand cone correlation test in accordance with ASTM D1556/D1556M for the first test and every twentieth test thereafter for each material type. Perform the sand cone test adjacent to the location of the nuclear test. For each transmittal including density test data, include a summary of all density correlations for the job neatly prepared on a summary sheet including at a minimum:

- a. Test identification number,
- b. Test location, including station/offset and project coordinates,
- c. Elevation of lift,
- d. Material type,
- e. Probe/hole depth,
- f. Moisture content by each test method and the deviation,
- g. Dry density by each test method and the deviation,
- h. Pass or Fail determination,
- i. Indication that test represents initial test or retest,
- j. Comments, including test method,
- k. Basis (test result) for maximum unit weight (reference proctor) or index density.
- l. Lift number (if appropriate),
- m. Photo number (if appropriate),
- n. Nuclear Densometer serial number and tester's/operator's initials.

3.21.3.2.4 Additional Testing

The Engineer may request additional tests if there is reason to doubt the adequacy of the compaction, or special compaction procedures are being used, or materials change or if the Engineer determines that the Contractor's testing is inadequate or the Contractor is concentrating backfill and fill operations in a relatively small area.

3.21.3.3 Testing by the Owner

During the life of this contract, the Engineer and/or Owner may perform quality assurance tests. The performance of such tests may temporarily delay the Contractor and must not be the basis for additional compensation and/or time. Make testing locations accessible to the Engineer and/or Owner to perform these tests.

3.21.3.4 Reporting

On a daily basis, furnish the inspection records and all material testing results, the quantity of fill placed, as well as the records of corrective action taken.

END OF SECTION