

# **CONSTRUCTION SPECIFICATIONS**

## **DIVISION V INDEX**

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**SECTION 16050**  
**BASIC ELECTRICAL MATERIALS AND METHODS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes: General requirements for providing basic electrical materials and methods.
- B. Related Work Specified in Other Sections Includes:

Certain items of equipment, and various control devices including conduit and wiring which are indicated on electrical drawings to be connected, but are specified in other sections pertaining to plumbing, equipment, control systems, and instrumentation. Install and connect these items to the electrical system as indicated or required in accordance with the Contract Documents.

- C. Overall Application of Specifications: This Section applies to all sections of Division 16 and to other sections that include electrical equipment requirements except when in these individual sections requirements are otherwise specified to provide and install all materials necessary for a complete operational system.

**1.2 DEFINITIONS**

**1.3 SYSTEM DESCRIPTION**

- A. Design Requirements: Design requirements are specified in the applicable sections.
- B. Performance Requirements: Performance requirements are specified in the applicable sections.

**1.4 SUBMITTALS**

- A. General: Provide all submittals, including the following, as specified in Division 1.
- B. Product Data and Information: Provide complete list of electrical equipment and materials to be furnished showing manufacturer, catalog number, size, type, voltage rating and other pertinent information.
  - 1. Provide catalog data on manufacturer's standard equipment and materials. Clearly indicate on catalog cuts the equipment and devices being proposed.
  - 2. Identification: Provide complete schedule and listing of system and equipment identification labels with legends.
- C. CONTRACTOR's Shop Drawings: Provide shop drawings on items manufactured for the Contract where specified.
  - 1. Provide connection diagram and schematic for each piece of electrical equipment. A manufacturer's standard connection diagram or schematic showing more

than one method of connection is not acceptable unless it is clearly marked to show the intended method of connection.

2. Provide diagrams showing connections to field equipment. Clearly differentiate between manufacturer's wiring and field wiring.
3. Provide raceway layout drawings showing conduits, boxes, and panels which contain the conductors to be provided. Include schedules listing conduit sizes and conductor content and identification.
4. Where additions and modifications are made to existing equipment, provide drawings which include both retained existing equipment and new Work.

D. Coordination Drawings: Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including but not necessarily limited to the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
  - a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
  - b. Exterior wall and foundation penetrations.
  - c. Fire-rated wall and floor penetrations.
  - d. Equipment connections and support details.
  - e. Sizes and location of required concrete pads and bases.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment during construction.

E. Record Documents: Prepare record documents, and in addition to the requirements specified in Division 1, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, and actual equipment and materials installed.

F. Maintenance Manuals: Prepare maintenance manuals, and in addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and catalog numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedure for routine preventative maintenance, and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

## 1.5 QUALITY ASSURANCE

- A. Codes: Provide all electrical Work in accordance with applicable local codes, regulations and ordinances. If there is a conflict between the requirements specified in the Contract Documents and the codes, follow the more stringent requirements as determined and approved.
- B. Testing: As a minimum, provide standard factory and field tests for each type of equipment. Other tests may be specified in the applicable equipment section.
- C. Labeling: Provide all electrical equipment and materials listed and approved by Underwriters Laboratories with the UL label or other OSHA recognized testing laboratories attached to it.
- D. Standard Products: Unless otherwise indicated, provide electrical materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design that conforms to these Specifications. When two or more units of the same class of material and equipment are required, provide the products of the same manufacturer.

## 1.6 DELIVERY, STORAGE AND HANDLING

- A. General: Deliver, store and handle all products and materials as specified in Division 1 and as follows:
- B. Shipping and Packing: Provide materials and equipment suitably boxed, crated or otherwise completely enclosed and protected during shipment, handling, and storage. Clearly label such boxes, crates or enclosures with manufacturer's name, and name of material or equipment enclosed.
- C. Acceptance at Site: Conform to acceptance requirements as required in Division 1.
- D. Storage and Protection: Protect materials and equipment from exposure to the elements and keep them dry at all times. Handle and store to prevent damage and deterioration in accordance with manufacturer's recommendations.
- E. Repair or replace all materials and equipment damaged by handling and storage as directed at no additional Contract cost.

## 1.7 PROJECT CONDITIONS

- A. General: The Drawings indicate the extent and general arrangement of the principal electrical elements, outlets and circuit layouts. Connect and install all electrical elements and devices to form a workable system as required by the Contract Documents whether the connections and installations are specifically stated in the Specifications or shown. Provide necessary materials and installation wherever required to conform to the specific requirements of the furnished equipment and for proper installation of the Work.
- B. Schematics: In general the runs of feeders are shown schematically and are not intended to show exact routing and locations of raceways. Verify actual and final arrangement, equipment locations, and prepare circuit and raceway layouts before ordering materials and equipment. Equipment locations are approximate and are subject to modifications as determined by equipment dimensions.
- C. Coordination of Work: Coordinate the Work so that the electrical equipment may be installed without altering building components, other equipment or installations.
- D. Departure from Design: If departures are deemed necessary due to structural conditions, obstructions or other problems, provide details of such departures and the reasons for requesting approval as soon as practicable but not later than the submittal of the raceway layout drawings. Do not make any departures without written approval.

## PART 2 PRODUCTS

Not Used

## PART 3 EXECUTION

### 3.1 ROUGH-IN

- A. Final Location: Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

### 3.2 ELECTRICAL INSTALLATIONS

- A. Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
  - 1. Coordinate electrical systems, equipment, and materials installation with other building components.
  - 2. Verify all dimensions by field measurements.
  - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
  - 4. Coordinate the installation of required supporting devices and sleeves to be set in cast-in-place concrete and other structural components, as they are constructed.
  - 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the ENGINEER for resolution.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other systems and components, where installed exposed in finished spaces.
10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
11. Install access panel or doors where units are concealed behind finished surfaces.
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

### 3.3 CUTTING AND PATCHING

- A. Perform cutting and patching as specified in Division 1. In addition to the requirements specified in Division 1, the following requirements apply:
  1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
    - a. Uncover Work to provide for installation of ill-timed Work.
    - b. Remove and replace defective Work.
    - c. Remove and replace Work not conforming to requirements of the Contract Documents.
    - d. Remove samples of installed Work as specified for testing.
    - e. Install equipment and materials in existing structures.
  2. Cut, remove, and properly dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work. Deliver all the existing removed to the OWNER as directed.
  3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
6. Patch and Seal finished surfaces and building components using new materials as specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

END OF SECTION

**16101**  
**GENERAL ELECTRICAL PROVISIONS**

PART 1                      GENERAL

1.01 SCOPE

- A. Provide and install equipment, material, labor, supervision, and operations related to electrical, controls and instrumentation work in accordance with General Conditions, applicable Drawings, Specifications, or required for the complete and satisfactory operation of a new Pump Filling Station for the Alabama State Port Authority located at McDuffie Island and subject to the terms and conditions of the Contract, including but not limited to the following items of work:
1. Power/Electrical System
    - a. Add a new feeder Circuit Breaker as indicated on the Drawings.
    - b. Wire and conduit for a feeder from the added Breaker to the new pump station in a reinforced concrete red Ductbank.
    - c. Duct bank installed by Others under a separate Contract. Contractor shall extend raceway at both ends of Ductbank as required for connection to feeder Circuit Breaker in Electrical Building and new Power Panel located adjacent to Main Pump Control Panel. See Drawings for additional information and requirements.
  2. Lighting System
    - a. A new pole mounted area LED flood light with a weatherproof toggle switch mounted on the pole in a weatherproof box.
  3. Control System
    - a. Installation of a Complete and Functional Pump Control Panel, Sub-Panels, Radio Link, and other components listed below.
    - b. Installation of Power and Control Wiring and Conduit from the new Pump Control Panel to Sub-Control Panels, Truck Mounted Control Panel with Radio Link, Strainer Sensors, etc.
    - c. New Level Transducer and Float Switches in the Wet Well.
  4. System and Equipment Grounding
    - a. Equipment Grounding Conductor with the feeder to the Control Panel
    - b. Equipment Grounding Copper Conductor for All branch circuits
    - c. Supplemental Grounding Conductor external to the Ductbank and Grounded as indicated at Both Ends of Ductbank per NEC Requirements in addition to as indicated on the Drawings.
    - d. Supplemental Grounding Rods and Grounding Electrode Conductors to the Control Panel and per 101.A.4.e above.
  5. Utility Work (N/A)
  6. All excavating, backfill, and concrete work required in conjunction with electrical work.
  7. Generator receptacle.
  8. All demolition and/or relocation or removal of existing equipment and wiring as indicated or required.
  9. Testing and adjusting.
  10. Connection of Electrically Powered Mechanical Equipment and associated controls.
  11. Temporary Construction Power
  12. All Incidentals Necessary for a Complete and Fully Functional Electrical System.
  13. Related work specified elsewhere in this and other specifications.



- B. Complete other directives herein with the understanding that terms such as “provide” or “furnish” includes Providing and Installation unless otherwise noted.

## 1.02 COMPLIANCE WITH CODES, STANDARDS AND REGULATIONS

- A. Provide equipment and installation that is in conformity with these Specifications and applicable requirements of the following:
  1. National Electrical Code (NEC) and local inspection agency.
  2. Local and/or state building codes.
  3. The local utility company.
  4. American National Standards Institute (ANSI).
  5. National Electrical Manufacturers Association (NEMA).
  6. National Electrical Safety Code.
  7. Institute of Electrical and Electronic Engineers (IEEE).
  8. Underwriters' Laboratories, Inc. (UL)

## 1.03 SUBMITTALS – FOR REVIEW

- A. Submit information in accordance with procedures described herein and the general conditions of the contract where applicable.
- B. Shop drawings are defined as drawings, diagrams, illustrations, schedules, performance charts, brochures and other data prepared by the Contractor which illustrate how specific portions of the work shall be fabricated and/or installed.
- C. Shop drawings are not part of the Contract Documents, but are a supplementary means of communications to assist in the understanding of what the Contractor proposes to provide and to establish that whatever he intends to install either does or does not conform to the Drawings and Specifications.
- D. No material shall be purchased or fabricated especially for this Contract until the required shop and working drawings have been submitted and reviewed as conforming to the Contract requirements. All materials and work involved in the construction shall then be as represented by said drawings.
- E. The Engineer's review of shop and working drawings will follow a general check made to only ascertain conformance with the design concept and functional result of the project and compliance with the information given in the Contract Documents. The Contractor is responsible for details and accuracy, for conforming and correlating all quantities and dimensions at the job site; for information that pertains solely to the fabrication processes or to techniques of construction; and for coordination of the work of all trades.
- F. The Engineer and/or Owner reserves the right to approve or disapprove any and all equipment based upon evaluation. Approval for fabrication and installation will be made only after submittal and review of all shop contract documents. The information required for approval shall include the following items.
  1. Electrical schematics
  2. Enclosure dimensional drawings
  3. Complete layout drawing with dimensions.
  4. Manufacturer data sheet for all components.
  5. Complete bill of material
  6. User operating manual.
  7. Installation instructions
  8. 2-year Minimum Warranty after Final Acceptance certificate unless indicating otherwise.

- G. Any deviations from the specifications and/or drawings shall be identified in the Submittal and No exceptions will be allowed after submittal approval.

#### 1.04 SUBSTITUTIONS

- A. The Engineer may consider proposals for substitution of materials, equipment, methods and services only when proposals are accompanied by full and technical data and all other information required by the Engineer for the proposed substitution. Substitution of materials, equipment, methods and/or services is not allowed unless such substitution has been specifically approved by the ASPA PM and Engineer.
- B. In the instance of a request for a substituted item, the Contractor shall verify that it is Fully equivalent in all respects and that it will fit into the space allocated to the originally required item giving due regard to all other trades' requirements.

Where modifications to the Contract Documents are proposed, the Contractor must clearly indicate such deviation in writing in his transmittal letter. If the modification and/or substitutions are agreed to by the Engineer, the Contract Documents will be appropriately modified.

However, when additional engineering or design work is required, the Contractor is advised that he must pay the Engineer for redesign to accommodate the revised substitution as well as pay other contractors for extra work required by them for the change.

No increase in Owner's construction cost will be allowed.

- C. For standard manufactured items considered by the Engineer as not requiring special Shop Drawings, the Contractor shall submit PDF files of manufacturer's catalog sheets showing model numbers and illustrated cuts of the items to be furnished, scale details, sizes, dimensions, performance characteristics, capacities, wiring and control diagrams and all other pertinent information. This information shall be highlighted on all copies when appropriate.
- D. The Contractor shall submit for review five (5) Copies of shop and working drawings of materials fabricated especially for his Contract, and of equipment and materials for which such drawings are specifically requested. PDF files of such drawings shall also be provided.
- E. The Engineer will retain three (3) copies and return two (2) copies to the Contractor submitting the documents.
- F. The Contractor shall submit three (3) copies of a letter with the Shop Drawings for each piece of equipment signed and certified by an authorized representative of the Equipment Manufacturer which certifies that the subject equipment meets or exceeds the current OSHA/ANSI, UL, and local industrial codes for safety. The letter shall also specifically identify any exceptions that the Equipment Manufacturer has taken in not providing the required safety devices as they relate to the above codes.
- G. Coordinate all equipment systems with the Drawings and submit a complete and coordinated shop drawing submission of the specific equipment system. All shop drawings related to the specific equipment system shall be submitted at the same time for review. The shop drawing submission shall provide the coordination of concrete foundations, piping, relative elevations, electrical, chemical facilities, instrumentation facilities, dimensions, structural changes, etc. in sufficient detail that the Engineer can adequately review the shop drawing. Equipment systems submitted which are incomplete and uncoordinated shall be returned to the respective Contractor, unchecked. A resubmission shall be made after equipment system shop drawings have been completed and coordinated.

Any required changes in the equipment system layout vs. the equipment system shown on the Drawings shall be provided by the respective Contractor at no added expense to the Owner or Engineer.

- H. To assure that manufacturers and suppliers are aware of the use to which their equipment and products will be subjected, the Contractor shall require the manufacturer or manufacturer's

representative to certify that they have examined the Plans and Specifications for this Project and have ascertained that this equipment or material is suitable for the purpose and use intended.

- I. When it is customary to do so, when the dimensions are of particular importance or when so specified, the drawings shall be certified by the manufacturer or fabricator as correct for this Contract.
- J. The Contractor shall be responsible for the prompt submission of all shop and working drawings in accordance with the shop drawing schedule so that there shall be no delay to the work due to the absence of such drawings.

#### 1.05 SUBMITTALS – FOR CONSTRUCTION AND CLOSE-OUT

- A. Final As-Built Drawings and Information
- B. Prior to final payment, provide six (6) updated operating, maintenance manuals and parts list, certifications and test reports.
- C. Warranties and Guaranties.

#### 1.06 GUARANTEE

- A. Guarantee to the Owner all equipment, materials and work provided for in accordance with the General Conditions or at least a period of two years after written Final  
Acceptance Date except for components that are specified for longer timeframe.
- B. Furnish Warranties in the Owners' Name for purchased items incorporated in the work to the Owner in accordance with the General Conditions.

### PART 2 MATERIALS

#### 2.01 MATERIALS

- A. All material shall be new, free from defects, of the quality specified or shown. Each type of material shall be of the same manufacture throughout the work. All material shall be the product of established, reputable manufacturers normally engaged in the production of the particular item being furnished.

#### 2.02 SUBSTITUTION OF MATERIALS

- A. In order to define requirements for quality, function, size, gauge, grade, and color, the Specifications have been written to describe materials and/or products of the first-named manufacturer.

Equivalent or better product of other unnamed manufacturers may be acceptable provided that:

1. Request are submitted 10 days prior to Bid Due Date to the Engineer for approval.
2. It meets all of the specified requirements for the item including UL.
3. Use of such substitute will not involve additional cost to the Owner or involve additional design by the Engineer.
4. Such substitute will not materially alter basic mechanical or structural design concepts.
5. Use is requested in accordance with procedures described in the General Conditions.

### PART 3 EXECUTION

### 3.01 GENERAL

- A. Prior to commencement of work, verify dimensions at site of work. Verify limitations of space available for installation clearances of all materials specified herein or indicated on the drawings. Bring discrepancies or differences to the attention of the Engineer for resolution.
- B. Workmanship shall be accomplished by persons skilled in performance of the required task. All work shall be done in keeping with conventions of the trade. Work shall be closely coordinated with work of other trades to avoid conflict and interference. Installation to conform to the applicable paragraphs of NFPA-70.
- C. Install materials and equipment as recommended by the Manufacturer, in addition to the requirements specified herein.
- D. Provide accurate layout, grades and elevations; set sleeves and openings in ample time. Provide all necessary supports required for the safe and proper installation of all materials and equipment. Install underground conduits, concealed conduits, boxes and sleeves in adequate time for other trades to complete concrete pours or other installation work.
- E. When not possible to install sleeves, inserts, etc., prior to other trades work being placed, cut openings, chases and trenches required for introduction of work and equipment, using approved methods. Do all backfilling and repair floors, wall and ceilings where cutting is done, in conformance with the various foregoing specification Sections.
- F. For electrical apparatus and wiring installed in hazardous locations, conform to code requirements for the particular class and division location.
- G. Repair or replace materials damaged during installation. Touch up scratched or marred surfaces.

### 3.02 STORAGE AND PROTECTION

- A. Store and protect all equipment in accordance with the manufacturer's recommendations.
- B. Coordinate on-site storage with Owner. Provide suitable off-site storage where no space is available on-site.
- C. Effectively protect, work, materials or equipment, which are liable to damage during the construction period.
- D. Cover all electrical control centers, instrument panels and all control panels furnished under these Sections of the Specifications with a heavy polyethylene plastic sheet during the construction period.
- E. Provide equipment which is stored in unheated or open areas with thermostatically controlled heating units of sufficient size to keep the temperature of the equipment above the dew point.
- F. Failure of the Contractor to protect the equipment as outlined herein and in accordance with the General Conditions shall be grounds for rejection of the equipment.

### 3.03 NATURE OF PLANS

- A. The plans are diagrammatic and indicate the general arrangement and intention of electrical work.
- B. Provide for all rough-in of electrical equipment, electrical connections including wiring and conduit completely coordinated with all other trades.
- C. Consult with other contractors to avoid conflicts with other trades.
- D. Field locate actual conduit routes and structural penetrations.
- E. Coordinate conduit stub-out locations to match equipment openings.
- F. Install electrical equipment providing proper working clearances.
- G. Record location dimensions especially for underground conduits on the As-Built Drawings.

### 3.04 ELECTRICAL WIRING AND CONNECTIONS

- A. It is the intent to have all electrically operated equipment, regardless of size, to be connected to perform its designed function; properly sized and in accordance with codes.
- B. Consult the Drawings and Specifications of other trades and provide all switches, wire, conduit and connections required to all electrical devices and equipment furnished by other trades unless specifically specified otherwise, even though not indicated on the electrical plans or called for in the specifications. The Contractor shall utilize the spare circuits in panel boards and motor control centers for these devices when necessary and as indicated on the plans.
- C. Outages: Power outages shall be kept to a minimum time and shall be Pre-Scheduled 10 days in advance with the ASPA Project Manager and Owner's operating personnel. Schedule outages on weekends or holidays, if needed. Control interruptions shall also be scheduled in advance and arrangements made for field manual controls. Provide all temporary services, cables, connections, as required to accomplish all tie-in and switch-over work with the minimum upset in the process. Remove temporary systems when the tie-ins are completed.

### 3.05 INSPECTION AND CERTIFICATION

- A. Provide support for all ASPA Inspectors and the Owner's representatives. Coordinate inspections with Owner's PM and Engineers. Repair or replace all defective equipment, materials or workmanship found by the Inspectors at No Additional Cost to the Owner.
- B. Obtain and deliver a final Certificate of Approval from ASPA Project Manager and Engineer upon completion of the work and before Final Acceptance for final payment.

### 3.06 TESTING AND ACCEPTANCE

- A. After the electrical installation is complete, the CONTRACTOR shall deliver to the Engineer the following information with his request for Final Inspection.
  - 1. One set of contract drawings marked to show all significant changes in equipment ratings and locations, alterations in locations of conduit runs, or of any data differing from the contract drawings. This shall include revised or changed panel board and switchgear schedules.
  - 2. Certificates of Final Inspection from ASPA Project Manager and Engineers.
  - 3. Provide tabulation of all motors listing their respective manufacturer, horsepower, nameplate voltage and current, actual running current after installation and overload heater rating.
  - 4. Documents listed in other SECTIONS not listed specifically herein.
- B. The electrical work shall be thoroughly tested to demonstrate that the entire system is in proper working order and in accordance with the plans and specifications. Each motor with its control shall be run as nearly as possible under operating conditions for a sufficient length of time to demonstrate correct alignment, wiring capacity, speed and satisfactory operation. All main switches and circuit breakers shall be operated, but not necessarily at full load. CONTRACTOR may be required during final inspection, at the request of the Engineer to furnish test instruments for use during the testing.

All panel board, Pump, and all other main feeder circuits shall be given a megger test using a 1000 volt megger. This test shall be performed after conductors are pulled, but before final connections are made. The Engineer shall be given two (2) days' written notice of the anticipated test date so that he may witness the test if so desired. In any event, the CONTRACTOR shall record the circuit designation and the megger reading on each phase. This written record shall be submitted to the Engineer. The cost of this test or any retest caused by insufficient megger readings shall be the responsibility of the CONTRACTOR.

END OF SECTION

## **SECTION 16110 RACEWAYS AND FITTINGS**

### **PART 1 GENERAL**

#### **1.00 SCOPE**

- A. Provide all labor, material and equipment to furnish and install raceways and fittings for all wires and cables.
- B. Raceways required may include, but not be limited to:
  - 1. rigid galvanized steel conduit (RGS)
  - 2. rigid galvanized steel conduit PVC coated (RGS/PVC)
  - 3. flexible metal conduit (FMC)
  - 4. liquid tight flexible metal conduit (LFMC)
  - 5. rigid non-metal conduit (PVC)
  - 6. electrical metallic tubing (EMT)
  - 7. cable tray (CT)
- C. Provide all raceways complete with fittings, mounting hardware and supports, installed as complete.

#### **1.01 REFERENCES**

- 1. Raceways shall be manufactured and installed in accordance with U.L., ANSI and NEC.
- 2. Raceways shall be listed by U.L. or other nationally recognized testing laboratory.

#### **1.02 SUBMITTALS**

- A. Provide manufacturer's data sheets.
- B. Data shall show compliance with NEC and UL listing.
- C. Provide estimated quantity of each type and size proposed for the job.

#### **1.03 PRODUCT DELIVERY: STORAGE: HANDLING**

- A. Comply with manufacturer's recommendations for storing PVC plastic conduit and PVC coated rigid steel conduit.
- B. Protection: Refer to the General Conditions.
- C. Environmental Conditions: Install work only when conditions of temperature and/or moisture are within limits of manufacturer's recommendations.

### **PART 2 PRODUCTS**

#### **2.01 CONDUIT**

- A. Rigid Galvanized Steel (RGS)
  - 1. RGS shall be hot-dip galvanized steel equal to that manufactured by Allied Tube & Conduit Corporation.
  - 2. NEC designated as Type RMC
- B. Rigid Galvanized Steel / PVC Coated (RGS/PVC)
  - 1. Conform to standards for RGS conduit, prior to plastic coating.

2. Zinc surface prior to plastic coating shall be conditioned to provide an anchor for the plastic coating. Galvanizing and plastic coating shall be performed in the same plant.
  3. The plastic jacket shall be bonded to the metal with a thickness between .035 inch and .045 inch the full length of the pipe except the threads. A coupling shall be furnished loose with each length of conduit and shall have a plastic sleeve extending one pipe diameter or 2 inch (whichever is more) beyond the end of the coupling. The plastic coating shall be factory applied by the same manufacturer who produces the hot-dipped galvanized conduit. The plastic coating shall be 40 mils thick.
  4. A two (2) part red urethane, chemically cured coating shall be applied to the interior of all conduit and fittings. This internal coating shall be applied at a nominal 2 mil thickness.
  5. The inside diameter of the sleeves on fittings shall be the same as the outside diameter of the coated conduit used with it. The wall thickness of the sleeve shall be the same as or greater than the plastic jacket on the conduit.
  6. Bond between metal and plastic shall be equal to or greater than the tensile strength of the plastic coating.
  7. RGS/PVC shall be equal to that manufactured by Robroy Industries.
- C. Flexible Metal Conduit (FMC) shall be Liquid Tight Conduit (LFMC)
1. Galvanized flexible steel conduit core with gray extruded PVC jacket; minimum size: 3/4 inch.
  2. Manufacturer: American Brass Co., Anaconda, Electri-Flex Co. Type LA, or equal.
  3. NEC designated as Type LFMC.
- D. Rigid Non-metal Conduit (PVC)
1. Unless otherwise indicated otherwise on drawings or not exposed to damage, Schedule 40, gray, minimum size: 3/4 inch.
  2. Where exposed to damage, Schedule 80, gray, minimum size: 3/4 inch.
  3. Manufacturers: Carlon, Sedco or equal.
  4. NEC designated as Type RNC.
- E. Electrical Metallic Tubing (EMT) shall Not be used unless approved by ASPA EE.
1. EMT shall be hot galvanized steel O.D. with an organic corrosion resistant I.D. coating.
  2. Minimum size: 3/4 inch for home runs, 1/2 inch may be used for dry interior individual lighting switch wiring.
  3. EMT shall be equal to that manufactured by Allied Tube & Conduit Corporation
  4. NEC designated as Type EMT.
- F. Cable Tray (CT)
1. Provide and install aluminum cable tray conforming to the latest edition of NEMA Standard VE-1, B-Line series 34 or equal.
  2. Size the cable tray to accommodate installed conductors plus a minimum of 20 percent space for future additions.
  3. Location shown on plans is diagrammatic in nature. Coordinate exact location with piping, structural, lighting and other systems. Do not penetrate tensioned concrete structures without approval of structural engineer. Submit support information to engineer prior to installation.
  4. General cable tray load class shall be NEMA 12C (12 ft span with 100lbs/ft) with a safety factor of 1.5. Maximum center-to-center rung spacing shall be 6".
  5. Spacing of cable tray should allow a minimum working space of 24" on one side of each tray. Vertical spacing of stacked trays shall not be less than 12" from top of side rail on lower tray to bottom of upper tray.

6. Provide UL listed fire stops when traversing a fire rated wall. Submit proposed method of penetrating all structural elements.
7. Provide expansion joints at intervals of 60 feet on long straight runs; or where expansions of approximately one-inch per 60 feet cannot be absorbed in fittings.
8. Install a #4/0 stranded bare copper ground conductor bonded to the tray Sections to form a continuous effective equipment ground. Terminate conduit risers to tray with insulated grounding bushings bonded to the #4/0 tray ground.

#### G. CONDUIT FITTINGS

1. For galvanized rigid steel conduit:
  - a. Description for 2 inch and smaller: Cast Grayloy body and cover Form 7 with gasketed wedge-loc clip cover with stainless steel screws and threaded hubs.
  - b. Description for 2-1/2 inch and larger: Cast malleable iron body and cover Mogul type with gasketed cover with stainless steel screws and threaded hubs.
  - c. Manufacturer: Appleton, Crouse-Hinds or equal.
  - d. Zinc alloy and similar soft metal castings are not acceptable.
2. For PVC coated rigid steel conduit use PVC coated cast metal fittings by the coated by the same manufacturer as the conduit.
3. For other conduit types use fittings recommended by the manufacturer and suitable for the application.
4. Submit data sheets for proposed fittings.

#### 2.02 EXPANSION JOINTS

- A. Description: Cast slip-joint fitting for conduit conductor for continuity of ground. with flexible bonding
- B. Material and Finish: Fittings of Grayloy, body of aluminum conduit, zinc coated. Use PVC fittings on PVC conduit, with neoprene O-rings.
- C. Manufacturer: Crouse-Hinds, Appleton, O-Z or equal.

#### 2.03 SURFACE RACEWAY

- A. Material: Steel, with primer and baked finish coat; paint to match walls.
- B. Standards: NEC Article No. 352
- C. Minimum Size: As listed by manufacturer for the number of conductors used
- D. Fittings: Designed by manufacturer for use with raceway system.
- E. Manufacturer: Wiremold, National or equal.

### PART 3 EXECUTION

#### 3.01 CONDUIT INSTALLATION SCHEDULE

- A. Install all control or instrumentation conductors in RGS or RGS/PVC whether overhead or underground.
- B. Underground Installations: PVC or PVC encased in concrete.
- C. Where a PVC conduit penetrates or passes through structural elements (footings, floors, walls, etc.) or rises above ground the conduit shall be changed to RGS/PVC with the appropriate adapter and fitting. There must be at least 2 feet of straight metal conduit underground after the transition.



- D. Exposed Outdoor Locations: RGC/PVC.
- E. Wet Interior Locations: RGC/PVC.
- F. Non-Process Buildings, Concealed Dry Interior Locations: EMT
- G. Exposed dry interior locations: RGS
- H. Connection in interior dry locations to equipment subject to movement caused by rotation, vibration or oscillation, connections from rigid conduit system to recessed lights, control devices or instruments and connections to dry-type transformers: FMC
- I. Connection in exterior locations or wet, damp or corrosive interior locations to equipment subject to movement caused by rotation, vibration or oscillation, motors, connections from rigid conduit system to recessed lights, control devices or instruments and connections to dry-type transformers: LFMC.
- J. Conduit installed in wet well: stainless steel
- K. Where indicated on drawings: Cable Tray
- L. Where indicated on drawings: Surface Raceway

### 3.02 CONDUIT INSTALLATION

- A. Size conduit in accordance with the NEC (3/4" min). Except in indoor office like areas, 1/2" conduit may be used appropriately for general wiring.
- B. Arrange conduit to maintain headroom and present a neat appearance.
- C. Install exposed conduit in a neat, symmetrical manner. Follow building contours, and run parallel and at right angles to structural members. Provide boxes, fittings and bends for changes of direction. Use channel racks for parallel runs. Fasten conduit securely in place and at intervals as required by the NEC.
- D. Maintain minimum 6 inch clearance between conduit and piping. Maintain sufficient clearance between conduit and heat sources such as flues, steam pipes, and heating appliances such that the conductor temperature ratings are not exceeded.
- E. Group conduit in parallel runs where practical and use conduit rack constructed of channel with conduit straps or clamps. Provide space for 25 percent additional conduit.
- F. Do not fasten conduit with wire or perforated pipe straps. Remove all wire used for temporary conduit support during construction, before conductors are pulled.
- G. Use conduit hubs or sealing locknuts for fastening conduit to cast boxes, and for fastening conduit to sheet metal boxes in damp or wet locations.
- H. Install no more than the equivalent of three 90-degree bends between boxes.
- I. Avoid moisture traps where possible; where unavoidable, provide fitting or junction box with drain fitting at conduit low point.
- J. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture.
- K. Provide No. 12 AWG insulated conductor or suitable pull rope in empty conduit, except sleeves and nipples.
- L. Install expansion joints where conduit crosses building or other structural expansion joints.
- M. Provide UL listed seals where conduit penetrates fire-rated building structures.
- N. Use concealed construction methods in all finished areas. Finished areas are the hung ceiling areas and offices.
- O. Do not run horizontally in unit masonry walls.

- P. Maintain a separation of 6 inches from hot water lines. Provide acceptable thermal insulation for electric lines where this separation cannot be maintained.
- Q. Keep all underground and exterior conduits watertight. Follow manufacturer's recommendations for sealing PVC coated rigid steel conduit. Coat all exposed digs and cuts promptly, before rust forms. Do not use pipe wrenches on coated conduit - use manufacturer's approved type friction wrench.
- R. Where PVC coated rigid steel conduit is used; stainless steel, PVC coated or fiberglass supports, struts, clamps and accessories shall be used.
- S. Separate systems of different voltage classes into different conduit systems unless otherwise noted.
- T. Terminate conduit in cast boxes in threaded hubs. Terminate conduit in sheet steel or fiberglass boxes with bullet hubs with insulating bushing. Provide threaded, corrosion resistant malleable iron fittings of other types as required for conduit. Provide grounding bushings on metal conduits entering fiberglass boxes.
- U. Do not pierce structural members without permission of the Engineer. Provide reinforcing for opening as determined by the Engineer.
- V. Where conduit passes through exterior walls, floor or roof, install appropriate fittings and materials to make openings watertight. Repair pierced vapor barriers.
- W. Provide sealing fittings for conduit entering, leaving, and/or passing through hazardous areas without exception whether or not it is called for on the drawings. Fill fitting with compound after installation of wires and testing.

### 3.03 UNDERGROUND CONDUIT/DUCT INSTALLATION

- A. Coordinate work with the installation of other structures or equipment that may be affected including by excavation, trenching and backfilling requirements.
- B. Conduits/duct shall be encased in reinforced concrete where installed under roadways, parking lots or otherwise subject to damage and as shown on the drawings. Concrete shall be died red.
- C. Make trenches true to grade. For circuits less than 600 volts, the minimum conduit depth is 24" except for special circumstances where encased in concrete as allowed by NEC. Slope conduits away from buildings and toward manholes or other necessary drainage. Accurately grade bottom of trench and remove rocks and loose dirt.
- D. During construction, protect conduits partially completed from entrance of debris such as mud, sand, docks and dirt by means of suitable temporary plugs.
- E. Stagger the joints of conduit rows and layers to provide maximum strength. Terminate PVC conduits with end bells and neatly grouted in place where entering manholes or pull boxes.
- F. Immediately following backfill and compaction, draw a testing mandrel not less than twelve (12) inches long with a diameter  $\frac{1}{4}$  inch less than the conduit diameter through the conduit. Conduits that fail the test shall be replaced at no additional cost to the Owner.
- G. After successful testing, plug all conduits terminating in manholes, service boxes or pull boxes. Plug conduits entering buildings with watertight compression type plugs.
- H. Where not encased in concrete:
  1. Place each row of conduits, securely spaced horizontally on struts, on a level at least three (3) inches thick bed of sand
  2. Covered with a uniform layer of sand to the depth required for separation
  3. Repeat for each succeeding layer until covered to a depth of six (6) inches over the highest conduit.

- I. Where encased in concrete:
  - 1. The concrete encasement shall be rectangular in cross-Section and shall provide at least three (3) inches of concrete between conduit and/or reinforcing and earth on all sides, top and bottom. Separate conduits by at least two (2) inches with power conduits separated from control or communication conduits by at least four (4) inches.
  - 2. Reinforce duct with a #4 steel reinforcing bar at the top and bottom corners of the duct running lengthwise and at one (1) foot intervals at the bottom running crosswise. Secure reinforcing bars with #18 black annealed steel tie wires.
  - 3. Support conduits with interlocking PVC spacers at 5 feet intervals. Use concrete blocks to support the spacers.
- J. Terminate PVC risers to grade with end bells where they terminate inside equipment enclosures such as transformers and switchboards. Risers from PVC conduits that are exposed above grade shall be rigid steel. Transition from PVC to rigid steel at least two (2) feet before riser.
- K. Install 3 inch wide marking tape 12 inches below finished grade. Tape

### 3.04 EXPANSION JOINTS

- A. Provide expansion joints where raceways cross building expansion and control joints or for long runs to prevent buckling. Maintain continuity of raceway grounding system by attaching bonding jumper as recommended by manufacturer.

### 3.05 SLEEVES

- A. Provide sleeves where conduits pass through masonry or concrete construction. Sleeves in load bearing walls, floors and/or beams shall be Schedule 40 galvanized steel pipe based on prior approval of Architect or Structural Engineer. Sleeves in other masonry walls or core-drilled openings shall be galvanized sheet metal, fiber or other approved material. Cover ends of sleeves with plates where they are visible. Seal sleeves watertight after installation of raceways. All conduits and/or sleeves passing through fire rated assemblies shall be fire stopped.

### 3.06 PERFORMANCE

- A. Install all wiring materials in a neat workmanlike manner, with all supports and fittings mechanically secure. Connect all metal raceways tightly to provide a continuous and effective ground path for faults and stray currents.
- B. Use conduit of sufficient size to allow the installation of the required number of wires or cables without injury to the insulation or excessive strain on the conductors (increase conduit sizes on long pulls).
- C. Consider each run of conduit individually for wet locations, where exposed to weather or there is a possibility of condensation and provide seal and drain fittings. In any case use seal and drain fittings in all vertical conduit runs where they terminate in pushbuttons, motors, and receptacles.
- D. Maintain proper bends, pull and junction boxes to keep within the cable manufacturer's recommendations for minimum bending radii of the conductors.

### 3.07 ADJUSTING, CLEANING AND PROTECTION

- A. Plug or cap all open conduit ends including those terminating in boxes as soon as installed to prevent the entrance of moisture and dirt.
- B. Provide covers for all conduit fittings as soon as fittings are installed.
- C. Clean and dry all conduits before any wires or cables are installed.

END OF SECTION

**SECTION 16130  
WIRE AND CABLE**

**PART 1 GENERAL**

**1.01 SCOPE**

**A. Description of Work**

1. Provide all labor, material and equipment to furnish and install all wire and cable relating to the work shown on the Drawings and/or specified herein.

**1.02 SUBMITTALS**

- A. For Engineer's review, submit manufacturer's data sheets for each type of wire or cable showing suitability for the application and specification.
- B. Within 30 days after award of contract, submit an estimate of the quantity of each wire or cable for the project.
- C. Prior to installation, submit a 12" minimum length sample of each wire or cable for Engineer's review as requested.

**1.03 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Exercise care in storage and installation of wire and cable to avoid damage to conductors and their covering. Use an approved pulling compound as lubricant for pulling wires into raceway.

**PART 2 PRODUCTS**

**2.01 BUILDING AND PROCESS WIRE**

- A. Manufacturer: Triangle, General Cable, Anaconda, Phelps Dodge or equal.
- B. Standards: NEC Article No. 310, UL
- C. Conductors: All conductors shall be copper. For general building receptacles and lighting provide solid conductors for No. 10 and smaller. For process or equipment provide stranded conductors especially where subject to vibration. Control conductors shall all be stranded.
- D. Insulation: 600 volts; XHHW or THHN/THWN for power feeders; THHN or THWN for branch and control circuits. All insulation shall have minimum of 75degree C rating.
- E. Minimum size: No 14 for control wiring, No. 12 for all other unless otherwise noted.
- F. Conductors for variable frequency drives shall be shielded type TC as manufactured by Belden with shield grounded at the drive per manufacturer's instructions.
- G. Other types as indicated or required

**2.02 WIRE CONNECTORS**

- A. Manufacturer: 3-M, T & B, Ideal or equal
- B. Standards NEC Article No. 110
- C. Application: Conductors No. 10 and smaller, solid and stranded
- D. Description: Solderless pressure connector consisting of a spiral spring in metal cup or crimped metal sleeve, with skirted insulating cap.

**2.03 SPLICING MATERIALS**

- A. Manufacturer: T & B, O-Z, Burndy, 3-M or equal
- B. Standards: NEC Article No. 110
- C. Application: Conductors No. 8 and larger, solid and stranded
- D. Description: Solderless pressure connector, bolted saddle clamp type
- E. Insulation: Insulating filler and vinyl tape for dry locations, Thomas Betts Shrink - Kon Series 'HS' for wet locations.

#### 2.04 TERMINALS AND LUGS

- A. Manufacturer: AMP: Type PIDG or equal
- B. Standards: NEC Article No. 110
- C. Application: All conductor sizes where screw or stud terminals are used for solid and stranded conductors.
- D. Description: Pre-insulated; crimp type; vinyl insulation, color coded, for size; high conductivity copper for sizes up to #10; die applied tinned copper for sizes #8 and larger.
- E. Performance: Constructed to firmly grip the conductor with a support sleeve to completely enclose and grip during heat cycling and/or vibration.

#### 2.05 TAPE

- A. Manufacturer 3-M "Scotch or equal
- B. Manufacturer's Designation No. 33 Plus
- C. Material: 7 mil vinyl plastic
- D. Performance: Provide electrical insulation and mechanical protection in continuous temperature environment up to 105 degrees C.
- E. Application for circuits 600 volts and below.

#### 2.06 SIGNAL AND CONTROL CABLE

- A. Instrumentation Signal Systems: For all analog signal systems and electronic signals for process control and monitoring. Standards: NEMA, ISA, and NEC Article No. 725
- B. Manufacturer: Belden; Dekoron Div., Samuel Moore & Company; Okonite Company; Manhattan Electric Cable Corp., or equal.
- C. Description:
  - 1. Single shielded twisted pair cables shall have stranded #16 AWG, tinned copper conductors; color coded polyethylene insulated; aluminum foil with mylar backing shielding with stranded, tinned copper, drain wire; and the assembly covered with 0.020 in. thick minimum protective black PVC jacket. Rating, 600 volts minimum.
  - 2. Multi-pair cables consisting of shielded twisted pairs of stranded, tinned copper conductors, numbered pairs, individually polyethylene insulated, paired assembly covered with cable tape and mylar backed aluminum foil shield with stranded, tinned copper drain wire; 0.040 in. thick minimum black PVC jacket overall. Rating 600 volts minimum.
  - 3. Minimum wire size for multi-conductor/multi-pair shall be No. 16AWG; larger AWG sizes as needed to comply with required pulling tensions. Cable construction characteristics to be selected to meet the extreme temperatures and moisture conditions.
  - 4. All cables shall have color coded or numbered pairs,

#### 2.07 CONTROL EQUIPMENT AND SYSTEMS

- A. Control Cables for circuits not exceeding 600 volts: Comply with standards of NFPA 79 Electrical Standard for Industrial Machinery, NEMA, NEC, and UL- Manufacturer: American Wire Company; Triangle Company Cable Corp.; or equal.
- B. Description
  - 1. Single conductors, stranded copper, sized, as required by NEC and as indicated, MTW/THHN/THWN insulation, rated 600 volts. Use red colored insulation for control circuits, with numbers on both ends of all wires.
  - 2. Multi-conductor, stranded copper, flame-retardant, with binder tape and PVC or polyethylene protective jacket, individual wires as specified for single conductors, 600 volts rated.
  - 3. Minimum wire size No. 14AWG; larger sizes shall be provided to comply with ampacity, voltage drop and required pulling tensions.
  - 4. Cable construction characteristics to be selected to meet the extreme temperatures and moisture conditions.
  - 5. Single conductor cables shall have color coded wires and groups per NFPA 79 as follows:
    - a. BLACK: Line, load and control circuits at line voltage.
    - b. RED: AC control circuits at less than line voltage
    - c. BLUE: DC control circuits
    - d. YELLOW: All control circuits or wiring that may remain energized when the main disconnect means is in the off position. Interlocking conductors shall be yellow throughout the entire circuit, including wiring in the control panel and the external field panel.
    - e. GREEN: Equipment grounding conductors (with or without one or more yellow stripes).
    - f. WHITE: Grounded (current-carrying) AC circuit conductor.
    - g. WHITE WITH BLUE STRIPE: Grounded (current-carrying) DC circuit conductor.
    - h. See exceptions allowed 1-6 in NFPA 79.

## 2.08 TERMINAL BLOCKS

- A. Manufacturer: Weidmuller, Phoenix, Allen-Bradley, or equal
- B. Standards: Underwriters Laboratory
- C. Description: Screw-clamp type which compresses wire between two surfaces without the clamping screw being in direct contact with wire; terminals shall be of the dead front design.

## PART 3 EXECUTION

### 3.01 INSTALLATION, APPLICATION, ERECTION

- A. Use an approved pulling compound as lubricant for pulling wires raceway.

### 3.02 CABLE INSTALLATION

- A. Support conductors in vertical raceways in accordance with NEC requirements. Provide manufactured clamps or compression fittings in bottom of panel boards if space permits, or provide separate pull boxes for such fittings where indicated.

### 3.03 CABLE TERMINATIONS AND CONNECTIONS

- A. Use insulated crimp type terminals on all control wiring, except at terminal blocks.
- B. Use proper crimping tools as recommended by manufacturer for crimp type terminals and/or connectors.

### 3.04 OVERSIZED WIRING

- A. Where oversized wiring has been indicated to overcome voltage drop and does not fit properly into the equipment served, provide a suitable junction box adjacent to the equipment for the change of wire size.
- B. Provide reduced wire size from junction box to equipment. Keep the reduced wire size as large as possible, but in no case use wire of ampacity less than that required by NEC to feed the equipment.

### 3.05 TAPING

- A. Apply plastic electrical tape at all equipment terminals, lugs, connections- or splices; tape insulation shall be equivalent to that of the original insulation.

### 3.06 PERFORMANCE

- A. Ascertain from serving power company phase identification at the point of connection; and thereafter carry out and maintain this phase positioning and color code, as specified herein.
- B. Verify phase rotation after all terminations at equipment have been made, by producing a 1-2-3 rotation on a phase sequence meter when connected to "A", "B" and "C" phases.
- C. Pulling tension on cables shall not exceed manufacturer's recommended limits.
- D. Verify sizes of all conductors shown and if smaller than local, state or NEC codes, increase the size to comply with the above requirements.

### 3.07 SIGNAL AND CONTROL CABLE

#### A. General

1. Size cables and associated conduits large enough to keep pulling tension below manufacturer's recommended limits.
2. Use wires and cables of sufficient length to make continuous runs. Splicing of shielded signal cable will not be permitted. unless indicated in junction boxes and manholes, and then only with approved terminal blocks and/or water-proof kits.
3. Furnish a separate raceway system for shielded signal cable. Do not run in the same conduit with power cable. Signal cables may run with 24 VDC power.
4. Where electronic signal cables are run in the same conduit bank with power cables, use galvanized steel conduit or route in a separated trench at least 18 in. away from power conduits. Use separate junction boxes and manholes to maintain isolation for signal cables.
5. Ground cable shield drain wire at termination in instrumentation cabinets only. Install heat-shrink tubing over the exposed end of the cable jacket and shield, with the shield drain wire not terminated at the field end (turn back under shrink tubing).
6. Electronic and Instrumentation Signal Systems
7. Separate conduit and wireway runs are required for this category. All wiring is to be isolated from all power systems.

#### B. Control Systems

1. When multi-conductor cable consisting of unshielded twisted pairs is used, the overall shield should be grounded only at the control panel end, computer, or RTU as specified.

### 3.08 FIELD QUALITY CONTROL

- A. Take the following readings on systems 600 volts and below.
- B. Megger tests of all feeders and motor circuits.
- C. Ammeter readings on all phases of all feeders.
- D. Continuity tests of all feeders.

E. Power Cables above 600 volts (MV Cables).

1. High Potential Direct Current tests shall be completed on all MV cables in accordance with manufacturer's recommendations. Unless there is a conflict with the manufacturers, tests shall be conducted with the following procedures. Cable tests to be performed by Certified testing organization. Contractor shall be responsible for all costs associated with cable testing and scheduling. Certified Cable Test Results shall be provided to the Owner.
2. Cable Tests shall be made after all termination kits have been installed and with the cable installed in the conduit, but disconnected from all equipment. Contractor shall be responsible for providing safety watch of both ends of cable during testing.
3. A dielectric absorption megger test shall be made with a 2.5 KV motor driven megger. Megger shall remain connected until a level-off reading is obtained. The cable shall be meggered before and after the High Potential Test is performed.
4. D.C. high potential tests shall be applied between one conductor and ground with all other circuit conductors and metallic shield grounded to the same ground. Each conductor shall be tested in a like manner. Negative polarity of the test set shall be applied to the conductor.
5. Current readings during D.C. high potential tests shall be taken at 30 second intervals during the first two minutes of the test and at 1 minute intervals during the remainder of the test. No test will be approved where there is a continual increase in leakage current through the test period.
6. The duration of the Direct Current Test shall be 15 minutes. The D.C. test voltage for the High Potential Tests shall be in accordance with the manufacturer's recommendations.
7. Certified Test Reports shall be supplied to the Owner's Representative for all MV cable tests.
8. The Contractor must obtain approval of all test reports from the Owner's Representative. The Contractor at no expense to the Owner shall correct all failures under test due to defective Contractor furnished material or poor workmanship.

END OF SECTION



## SECTION 16160

### PUMP CONTROL PANELS AND CONTROLS

#### PART 1 GENERAL

##### 1.1 DESCRIPTION

- A. The Pump Control Panels shall be supplied containing all the electrical and mechanical equipment necessary to provide for the operation of One electrical pump. Panels shall include provisions for turning pump on and off, manually and automatically as indicated, indications for operation and alarm conditions, testing and indication of all operational features, and terminal strip wired and indicated for all Contacts. See Drawings for additional requirements. A minimum of 4 spare terminal strip contacts in the Main Control Panel shall be provided to allow for expansion, repair or alterations.
- B. "Pump Control Sub-Panel" and Truck Mounted "Remote Control Panel" shall provide all functions remotely from the Main Control Panel and include indicators as specified and indicated.

##### 1.2 QUALITY ASSURANCE

- A. All work shall comply with the applicable codes, standards, rules and regulations published by NEC, NFPA, OSHA, IEEE, ANSI, UL, National Electric Safety Code and NEMA Standard IC-1 Industrial Control.

##### 1.3 SUBMITTALS

- A. Shop drawings shall be submitted showing layout materials and components for Control Panels as specified and on the drawings.

#### PART 2 PRODUCTS

##### 2.1 GENERAL

- A. The Control Panel, Sub-Control Panel, and Remote Control Panel shall be NEMA 4X, Type 304, 14 Gauge Stainless Steel with continuous welds on all seams. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. A neoprene gasket attached with oil resistant adhesive and held in place with stainless steel retaining clips shall be installed around the door. All hardware except the print pocket shall be stainless steel. The outer door shall contain a self-storing wind resistant rod.
- B. Visible from the exterior of the enclosure shall at a minimum be a Power Available Light, High Level Alarm Light, Alarm Light and Horn, Alarm Reset Button, Filtered air vents, and as specified below. All parts mounted to the enclosure shall be secured with stainless steel hardware and be suitable to maintain NEMA 4X rating. Indicate clearly in Submittals.

- C. The power subpanels shall contain a main circuit breaker, emergency circuit breaker, motor circuit breakers, control circuit breaker, duplex 120V/20 Amp receptacle breaker, soft motor starter with over load protection on each leg, control voltage fuse transformer, alternator. All control wiring shall be color coded per IPCEA (minimum 18 colors) size 18 AWG, rated for 300 V, 80 degrees C, stranded, tinned copper with PVC phase monitor, relays, terminal strips, GFCI 120V/20 Amp duplex receptacle, trouble light and neutral block. The main circuit breaker shall be HVAC rated due to repeated switching.
- D. The inner dead front door shall be constructed of .25" clear Lexan. The inner dead front shall have rounded edges and shall be mounted on an .063" aluminum continuous aircraft hinge with a stainless steel pin. The inner dead front shall be fastened to the enclosure and hinged with stainless steel screws. The dead front shall be supported on the vertical break opposite the hinge with a continuous support and shall not depend on breakers or other components. The inner dead front shall contain breaker knock-outs for protrusion of the breaker handles. Mounted on the inner dead front door shall be level lights, pump run lights, elapsed time meters, HOA switches, 3 position alternator mode switch, trouble switch and thermal overload reset buttons. All components shall be equal to and directly interchangeable with those listed on the drawing.
- E. Main Control Panel shall be provided with a phase monitor and surge protection to ensure protection for Pump circuit.
- F. The Panels shall be provided with a LED Convenience Light to illuminate the interior of the panels at night. The switch for this light shall be a heavy duty single pole switch located on the inner dead front door.
- G. Provide two 2 inch diameter conduit knockout holes for electrical conduit mounting in the bottom of the Main Control Panel Cabinet. The knockout shall be located by the CONTRACTOR to suit junction box and taped closed for shipping.
- H. The Ground Fault Protected (15 amps) Duplex Receptacle shall be mounted internally in the bottom of the Panels in an aluminum junction box.
- I. Main and Sub Control Panels shall have a control transformer, where required, to provide 120 volts single phase A.C. control power. Both legs of the primary shall be protected by a thermal magnetic Type FA 2 pole circuit breaker minimum frame size as manufactured by the Square D Company, one leg of the secondary of the control transformer shall be protected by a thermal magnetic, Type FA circuit breaker minimum frame size as manufactured by the Square D Company, the other leg shall be grounded. The capacity of the control transformer shall be adequate to operate all the control devices in the circuit to include power for motor space heaters (for motors

20 HP and above coordinate with motor manufacturer) with a minimum capacity of 0.75 KVA.

- K. Lightning arrestor, GE or equivalent, sized for voltage, current and phase for particular installation as approved by the ENGINEER and mounted on the outside bottom of the disconnect box.
- M. The following Control Panel Components shall be included along with others specified:

**MAIN PUMP CONTROL PANEL BASIC COMPONENTS:**

SELECTOR - PUMP START/STOP,  
INDICATOR - PUMP LOW LEVEL SHUTOFF,  
INDICATOR - STRAINER HIGH PRESSURE SHUT OFF,  
INDICATOR - PUMP RUN MODE,  
INDICATOR - PUMP LOW LEVEL SWITCH,  
SWITCH - AREA LIGHTS ON-OFF

**PUMP CONTROL SUB-PANEL BASIC COMPONENTS:**

INDICATOR - PUMP LOW LEVEL SHUTOFF,  
INDICATOR - STRAINER HIGH PRESSURE SHUT OFF,  
INDICATOR - PUMP RUN MODE,  
SELECTOR - PUMP START/STOP,  
INDICATOR - PUMP LOW LEVEL SWITCH,  
SWITCH - AREA LIGHTS ON-OFF

**REMOTE PUMP CONTROL PANEL MOUNTED IN TRUCK**

RADIO LINKED TO MAIN PUMP CONTROL PANEL  
SELECTOR - PUMP START / STOP ;  
INDICATOR - PUMP RUN MODE;  
INDICATOR - PUMP LOW LEVEL SHUTOFF ;  
INDICATOR - STRAINER HIGH PRESS SHUTOFF  
SWITCH - AREA LIGHTS ON-OFF

2.2 WIRING

- A. All wiring shall be neatly laced or shall be installed in plastic Panduit raceways. The raceways shall be sized so that not more than 50% of the design capacity is used.
- B. All terminations to external devices shall terminate on terminal blocks.
- C. All control wiring shall be color coded, minimum size 16 AWG rated for 300 volts, 80 C, stranded tinned copper PVC insulated.

- D. A laminated wiring and circuit schematic sized 11 inches by 17 inches shall be permanently affixed to the interior of the enclosure door.. The schematic shall be extruded vinyl homopolymer laminate or approved equal.  
Also included in door shall be a print pocket large enough for an 8.5" x 11" clipboard to be mounted at start up.
- E. Aluminum warning signs with legend "DANGER-HIGH VOLTAGE" and NEC required Arc Flash Labeling shall be mounted on the exterior main panels door. The warning sign design and colors shall be in accordance with OSHA specifications and must be permanently affixed to Enclosure Door exterior without screws or rivets.  
(No holes to be drilled in exterior door).
- E. All wiring shall be color coded, numbered, and labeled as shown in the drawings.

### 2.3 NAME PLATES

- A. Each switch, circuit breaker, indicating light, push-button, meter, relay etc. shall have an engraved laminated plastic background color coded nameplate mounted above for proper identification:

Red for alarm and emergency breaker,  
Black for power,  
Green for level, and  
Blue for controls.  
Letters shall be a minimum of 1/4 inch in height.

### 2.4 OPERATION

- A. The control function provides for the operation of the Pump under normal conditions. Pump will be shut off at the elevation shown on the plans.

In the event of a malfunction or a flow that exceeds the capacity of the pump an Audible high level alarm and Alarm Light will be activated to indicate high level condition at the site.

A reset function shall lock out the audible alarm; however, the alarm light shall release only with the correction of the high level condition.

- B. In the event of phase reversal, loss of any phase, or low voltage of any phase, control voltage shall be interrupted through the phase monitor.

The phase monitor shall automatically reset upon removal of any and all of the above conditions.

### 2.5 SPECIAL

- A. The above panels and controls requirements describe a 480 volt, 3 phase power available complete as described above and also with Truck Mounted "Remote Control Panel" connected to Truck's 12 Volt DC.
- B. Truck Mounted "Remote Control Panel" shall communicate with Main Control Panel by Radio Link provided and installed by Contractor. Prior Coordination with ASPA to avoid using Terminal's Radio Frequencies and local operations is required.

## 2.6 RELAYS:

- A. Relay shall be general purpose plug in relay, 8 pin (DPDT) or 11 pin/blade (3PDT), with 480 VAC 10 AMP rated contacts. 24 volt coil relay shall have Octal-type mounting. 120 volt coil shall have square-base relay-type mounting. Relay shall be Syrelec model RPT-2C8-24A, RPT-3C11-24A, RKT-2C-110A, RKT-3C-110A, or approved equal.
- B. Time delay relay shall be general purpose 8 pin/blade or 11 pin/blade plug in timing relay with 24 VAC or 120 VAC coil, or time delay module in conjunction with standard relay above. Timing mode shall be on-delay adjustable for 0.5 seconds (maximum), to 30 seconds (minimum) with contacts rated at 480 VAC 10 AMP. 24 volt time delay relay shall be Turck Multi-prox, Inc., Time Cube CT2-E20 with Syrelec RPT-2C8,24A, or CT3-E20 with Syrelec RPT-3C11-24A, or approved equal. 120 volt time delay shall be Syrelec model K-AR2-F100-110 (K-AR2-F10-110 for relay - TD1) or K-AR2-B-110 or approved equal.
- C. 12 volt time delay relay shall be DIN Rail mounted with 12 volt DC coil, timing mode shall be on-delay adjustable for 1 second (maximum), to 90 seconds (minimum) will contact rated from 480 VAC at 10 amps. Time delay relays shall be Syrelec model B-AR-F100-12D, or approved equal.

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Control Panels shall be installed at the lift station sites as shown on the drawings.
- B. All work shall be in a neat and workmanlike manner by a certified master electrician holding a current competency card and registered with the State of Florida.
- C. Electrical work shall be coordinated so as not to interfere with or delay other construction operations.
- D. Perform all necessary cutting, sleeving, excavating and backfilling for the installation of the equipment and the restoration thereafter.
- E. Install all equipment and control devices furnished by equipment manufacturers with their equipment and complete wiring in accordance with manufacturer's

recommendations and approved wiring diagrams. Any OWNER furnished equipment will be connected by the CONTRACTOR.

- F. The ends of all conduits shall be carefully reamed free from burrs after threading and before installation. All cuts shall be made square. All joints shall be made up tight. Care shall be taken to see that all power conduit runs either from a permanent and continuous ground connection point, or a bond wire is provided within the conduit.
- G. The CONTRACTOR shall permanently and effectively ground service neutral and all raceways, devices, and utilize equipment in accordance with requirements of National Electrical Code, and as shown on Drawings.

### 3.2 ELECTRICAL WORK - GENERAL

- A. See Section 16050.

### 3.3 GROUNDING - SECONDARY VOLTAGE SYSTEM

- A. See Section 16450.

### 3.4 DISCONNECT SWITCH ENCLOSURE

- A. A heavy duty NEMA 4X lockable fused Disconnect Switch mounted in type 304 stainless steel enclosure. CONTRACTOR to use mounting as indicated. Holes shall not be drilled in disconnect box. Sized for voltage, current and phase for particular installation as approved by ENGINEER mounted in accordance with lift station drawing.

### 3.5 OUTSIDE LIGHTNING ARRESTOR

- A. A lightning arrestor, GE or approved equal, sized for voltage, current and phase for particular installation as approved by ENGINEER shall be mounted on the outside bottom of the disconnect box.

### 3.6 PUMP CABLE CONNECTORS AND SEALS

- A. CGB Connectors packed with removable sealants shall be installed in the Control Panels Enclosure and All Penetrations shall be from the Bottom of the Enclosure.

### 3.7 CONDUIT

- A. For all above ground conduit and installation, and from junction box into Panels shall be in RIGID GALVANIZED STEEL CONDUIT (RGS). See Section 16110.
- B. For all below ground conduit and installation and from junction box to wet well shall be

Non-Metallic Conduit Section Encased in concrete. See section 16110.

### 3.8 SPLICES

- A. All splices for conductors No. 12 through No. 6 AWG solid or stranded shall be made with "Scotchlock" spring connectors or the pressure wire type. For wire sizes larger than No. 6, splices shall be made with "OZ" Type "XW" or "XLP" as appropriate to the splice being installed. Equal fittings of Brundy and Penn Union may be used. Tape shall be equal to Scotch No. 33 plastic over splice and filler tape on splices shall be equal to "Scotchfill". All Scotchlock splices in hand holes shall be dipped Glyptol for waterproofing.

### 3.9 PERMITS

- A. All required permits and inspection certificates shall be obtained and paid for by the CONTRACTOR and be made available to the OWNER at the completion of the work.

### 3.10 START-UP

- A. The manufacturer shall provide all necessary instruments and special apparatus to conduct any test that may be required to insure that the system is operating as designed. A written start-up report is required and must be furnished to OWNER within 5 days of start-up.

### 3.11 GUARANTEE

- A. Submit a written guarantee to the OWNER that all electrical work and material furnished provided under this contract is free of defects for a period of Two years after Final Acceptance by ASPA unless specified otherwise.
- B. There will be no additional charge to the OWNER to repair or replace any such work which is found to be defective within the guarantee period. Should a defect occur and the CONTRACTOR or his representative not be available for immediate repair, an interim repair by others may be made without violation of the guarantee.

END OF SECTION

**SECTION  
16450  
GROUN  
DING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes: Requirements for providing a complete grounding system as specified and shown. Grounding includes but is not limited to: motor control centers, electric equipment enclosures, transformers, unit substations, switchgears, switchboards, ground grid systems with grounding rods, grounding conductors, bonding jumpers, grounded conductors, water pipe connections, and building and miscellaneous structure metal frames.
  
- B. Related Work Specified in Other Sections Includes:
  - 1. Section 16050 - Basic Electrical Materials and Methods
  - 2. Section 16110 - Electrical Raceway Systems
  - 3. Section 16120 - Wires and Cables - 600 Volts and Below
  - 4. Section 16670 - Lightning Protection Systems
  - 5. Section 16950 - Electrical Testing Requirements

**1.2 REFERENCES**

- A. Codes and Standards: The following codes and standards are referred to in this Section:
  - 1. NEC - National Electrical Code ( Latest Edition )

**1.3 SUBMITTALS**

- A. General: Provide all submittals, including the following, as specified in Division 1.
  
- B. Product Data and Information: Provide manufacturer's catalog data for the following:
  - 1. Grounding and grounded conductors
  - 2. Grounding connectors, clamps and bushings
  - 3. Grounding rods
  - 4. Bonding jumpers
  
- C. Shop Drawings: Provide shop drawings showing the locations and length of grounding rods. Label the size and material used for grounding rods. Provide details pertaining to grounding electrode conductors, grounding and grounded



conductors, grounding connections and the ground grid for buildings, structures, lighting units, manholes and handholes.

D. Quality Control: Provide a field report of the system ground impedance test results.

#### 1.4 QUALITY ASSURANCE

A. Construct a complete grounding system in accordance with applicable ANSI, a IEEE standards and the NEC and local codes.

#### 1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

### PART 2 PRODUCTS

#### 2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Grounding and Grounded Conductors
  - a. American Insulated Wire Corporation
  - b. Rome Cable
2. Grounding Connectors, Clamps and Bushings
  - a. Burndy Corporation
  - b. O-Z/Gedner Company
  - c. Ezico Products
  - d. Thomas and Betts
3. Grounding Rods
  - a. Harger Lightning Protection, Inc.
  - b. Thomson Industries, Inc.
  - c. Carolina Galvanizing Utility Products Div.
  - d. Erico International Corp.

#### 2.2 MATERIALS

A. General: Provide conductor sizes as shown or required.

B. Materials: Use conductors in accordance with the requirements specified in Section 16120.

- C. Bare conductors: Use bare copper conductor where buried in earth, embedded in concrete or exposed.
- D. Insulated Conductors: Use copper conductor with green color insulation rated at 600 volts where installed in conduits or other enclosed raceways.

### 2.3 CONNECTORS

- A. Grounding Clamps and Bolted Connectors: Use grounding clamps and bolted connectors suitable for devices or cables being connected.
- B. Welding: Use the exothermic welding process for buried, concealed and accessible connections to structural members, ground rods, and case grounds. Clean and paint welds embedded in the ground or encased in concrete with asphalt base paint.
- C. Bolted Connectors: Use bolted connectors for grounding of ground buses and equipment.
- D. Pipe Grounding: Use copper, brass, or bronze grounding clamps for grounding pipes. Do not use strap type clamps for this purpose.
- E. Grounding Bushings: Provide grounding bushings for conduits where conduits are not effectively grounded by firm contact to the grounded enclosure.

### 2.4 GROUNDING RODS

- A. Length and Size: Provide grounding rods 3/4-inch in diameter and 10 feet long.
- B. Grounding Rod Material: Stainless steel.

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. General: Install conductors to preclude exposure to physical damage. Install connections firm and tight. Arrange conductors and connectors without placing strain on the connections. Bury equipment grounding conductors as shown, or at a minimum of 12 inches below grade. Bring loops or taps up for connection to equipment or other items to be grounded.
  - 1. Install an insulated grounding conductor in all conduits.
  - 2. When raceways are used to contain and protect grounding conductors, install in accordance with Section 16110 and NEC.

3. Where conductors are installed in nonmetallic raceway, install the grounding conductor in addition to the neutral wire, for system sized in accordance with NEC or as scheduled.
  4. Perform exothermic welding with properly sized molds.
- B. Grounding Rod Installation:
1. Install grounding rods as shown with the top of the rod a minimum of 12 inches below grade.
  2. Drive grounding rods into permanently moist soil.
  3. Provide additional ground rod sections as required to reach permanently moist soil.
  4. Install cast iron junction box without bottom for access to grounding rod and conductor where shown.
- C. Equipment Grounding: Ground each piece of electrical equipment using a conductor in the raceway feeding the equipment in accordance with NEC.
1. Unless specified otherwise, connect transformer enclosures and neutrals to the grounding system. Connect the neutral ground connection at the transformer terminal. Provide two separate, independent, diagonally opposite connections for power transformers so removal of one connection will not impair continuity of the other. Make the connection from the ground grid to the ground bus and enclosures of switchboards, switchgears and motor control centers, lighting and distribution panelboards, control, relay and instrumentation panels.
- D. Grounding Conductors: Connect the grounding conductor between the equipment and the grounding system. Where a ground bar is furnished with the panelboard, connect the grounding conductor to the bar.
- E. Miscellaneous Grounding: Provide grounding for the following:
1. Ground receptacles and switches and their metal plates through positive ground connection to the yoke/strap, outlet box and grounding system grounding wire installed in the conduit.
  2. Ground racks, supports, frames, covers and metal parts in manholes or handholes, controllers, motor frames, surge capacitors, arrestors, lighting fixtures, metal structures, exposed noncurrent carrying metal, mechanical equipment, hoist beams, cranes and similar items.

### 3.2 FIELD QUALITY CONTROL

Tests: Conduct a witnessed test to determine the ground impedance for the entire system using a ground loop impedance tester.

Provide a maximum impedance of 2 ohms at any point of the test.

Add additional grounding rods if necessary to meet this requirement.

END OF SECTION