

SECTION 24

ELECTRICAL MATERIALS AND METHODS

24.01 GENERAL

- A. These specifications shall form a part of the Contract Documents for electrical construction work for all buildings to be built or modified for the Board of Water and Sewer Commissioners of the City of Mobile, Alabama. The work covered by this section includes the furnishing of all parts, labor, equipment, appliances and materials and performing all operations in connection with the installation of electrical equipment.
- B. This standard shall govern, but not be limited to the following:
 - 1. Installation of air terminals, bonding, grounding and ground rods
 - 2. Branch circuit wiring, including conduits, wireways and supports, wire, outlets, switches, receptables, and circuits in conduits for items as shown on the drawings.
 - 3. Provide grounding systems including ground rods, connections to structural steel and equipment, buried counterpoise wires, Cad-weld joints and mechanical lugs as specified to meet codes.
- C. If surge suppressors are not in place in the existing equipment, add to all incoming power and signal lines, and all outgoing signal lines. The surge suppressors shall be as per the Mobile Standard for Water and Sewer Systems, Section 41 entitled "TRANSIENT VOLTAGE SURGE SUPPRESSORS".

24.02 SAFETY AND INSPECTIONS

- A. Observe all OSHA regulations in effect. Do not perform any construction work that is not in adherence to good safety practices. Wear all protective headgear, eye protection and safety shoes as required by OSHA safety regulations. Perform all electrical work on de-energized circuits. When observation (by opening enclosures) of energized equipment is required, wear OSHA approved full face guards, electrician's gloves and fire resistant overall suit. All panels and boxes shall have factory covers and metal enclosure

panels covering energized parts securely attached in place prior to energizing. Temporary covers made of other materials will not be allowed.

- B. Provide for inspection of all work by the Engineer and/or Owner's representatives having jurisdiction during the proper phases. Correct all deficiencies found in the work by the above inspectors.
- C. Prior to submitting the bid, the Contractor shall visit the site and familiarize himself with the existing conditions and facilities. No charges for additional payment for difficulties encountered due to existing conditions may be submitted.

24.03 CODES AND STANDARDS

- A. Comply with the latest editions of the codes of the following organizations listed as a minimum standard unless these specifications or drawings require a higher minimum standard:
 - 1. American National Standards Institute (ANSI)
 - 2. National Electrical Manufacturer's Association (NEMA)
 - 3. National Fire Protection Association (NFPA) Publication 70, National Electrical Code
Publication 101, Life Safety Code
 - 4. Underwriters' Laboratories, Inc. (UL)
 - 5. Factory Mutual (FM)
 - 6. Underwriters Laboratory UL 96A
 - 7. Underwriters Laboratory UL 96
 - 8. Institute of Electrical and Electronic Engineers (IEEE)

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9. Instrument Society of America (ISA)
10. Occupation Safety and Health Act (OSHA)

24.04 GROUNDING

- A. Non-Current Carrying Metal Parts of electrical items such as cabinets, enclosures, frames, etc. and the neutral conductor shall be grounded in accordance with the National Electrical Code unless additional grounding requirements are indicated. Grounding conductors, used inside shall be copper, sized as noted. Special grounding system features shall be provided as indicated. The backplane of all enclosures shall be connected to ground.
- B. All Conduit Runs installed for lighting power loads shall contain a grounding conductor throughout the entire length of the run forming a part of the grounding system. The grounding system shall be electrically continuous throughout the electrical system and shall be connected to earth ground at the point of power service and as otherwise indicated.
- C. Ground Rods shall be copper-coated steel type, 3/4 inch diameter, 20'-0" length, minimum. The top of the ground rods shall be driven to 1'-0" (minimum) below finished grade unless otherwise indicated and shall be electrically connected with suitable cad welding.
- D. Resistance to Ground of each ground rod shall not exceed 25 ohms when measured during dry weather. In the event this value is not obtained, one additional rod or rod selection equal to that tested shall be driven. Should the additional rod or section fail to achieve the required value, the Engineer shall be immediately notified. A written record of all resistance measurements and test dates shall be submitted to the Engineer prior to completion of the Project.

- E. All wiring connected to ground rods shall be Cad Welded.
- F. Ground wire shall be bare, rope lay class B Stranded aluminum annealed (soft down) above ground, and copper underground. Use wire number 4 or larger.

24.05 CONDUIT

- A. Galvanized Conduit shall be provided unless otherwise indicated and shall be heavy-wall, rigid type bearing the Underwriters Laboratories, Inc., label of approval. Conduit minimum size shall be 3/4 inch. Steel conduit and fittings installed through concrete shall be manufactured with an exterior 40 mil thick polyvinyl chloride bonded jacket "Plasti-Bond" by Robroy, or approved equal. Fittings for rigid steel conduit shall be threaded types made up with conductive waterproof compound. Poured seal fittings shall be provided as required by the National Electrical Code and shown on the drawings. Use 3/4 inch diameter minimum for metal conduits and 3/4 inch diameter minimum for PVC conduit. Size shall conform to NEC Standards for conduit fill.
- B. All Conduit shall be clean and free from dents, scars, or other deformities. Connections shall be made up watertight, and bushings shall be provided where smooth hubs are not encountered. Changes in directions shall be made with symmetrical bends or conduit boxes. Field-made bends shall be made with an approved hickey or conduit bending apparatus. Conduit runs shall be installed parallel or perpendicular to structural members. Conduit hangers and supports shall be provided at intervals recommended by the manufacturer and the National Electrical Code. Underground conduit runs shall be installed at least 1'-6" below finish grade unless other depths are indicated. Plain earth used for backfill shall be free from objectional material such as rocks, glass, metals, wood, etc., and shall be tamped to surrounding earth density.

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C. Rigid Conduit:

1. Rigid galvanized steel, with threaded fittings and condulets, with locknuts and plastic bushings at sheet metal enclosures. In process areas and where exposed on exterior, not exposed to chemicals, use rigid galvanized steel conduit throughout. Terminate with water-tight hubs, equal to Crouse-Hinds, Myers, or equal, at sheet metal enclosures and fixtures without threaded openings. Use rigid steel conduit where exposed in electrical rooms below 50 inches high (EMT not allowed below this height). Convert all PVC plastic conduit underground runs to PVC coated rigid galvanized steel at 6 in. below grade or concrete slabs, using a plastic female adapter concealed below grade or slab, except in chemical additive areas use only PVC conduit. Exception: In all areas lighting fixture stanchions shall be rigid galvanized steel, 1-1/2 in. minimum size.

D. Flexible Conduit: Galvanized steel interlocking coil, 1/2-inch diameter minimum. National "Flexsteel" or equal. Flexible conduit shall be provided where equipment vibration may exist, and where noted.

1. For process areas, equipment rooms, exterior and damp locations, use water-tight flexible conduit with gray polyvinyl jacket; "Seal-tite" or equal.

E. PVC Conduit: PVC conduit shall be used under slab, underground, and for sleeves protecting grounding wires coming up above grade. When under slab or underground, use schedule 40; 3/4 in. minimum size. Use grey PVC for vertical wires from air terminals to ground rods.

F. Fittings: Manufactured for service required.

1. Thread ends and apply locknuts and bushings on rigid conduit. Use galvanized cast malleable iron boxes and condulets for all exterior runs and area lighting (except chemical additive areas), and for changes in direction pulling, or branches. Use galvanized steel bullet hubs at sheet steel enclosures or fixtures without threaded entrances.

G. Pulling Wires: Jet Line No. 232, or equal, polyolefin, or nylon cord; working test load shall be 200 lb., minimum.

H. Contractor shall verify or establish electrical classification of building or facility before determining type of conduit to purchase. Use explosion proof conduit for junction boxes, fittings, and enclosures as required to meet building classification.

24.06 WIRE AND CABLE

A. Wire:

1. All wire to be aluminum, with permanently marked size, grade of insulation, voltage and manufacturer's name at regular intervals on outer covering (600 volt rating).

Wire shall be:

- a. Aluminum at outside areas and on top of buildings.
- b. All aluminum at lift stations, or sewer plants where hydrogen sulfide gases are present.
- c. Aluminum for connections between air terminals and ground rods.
- d. Cooper inside buildings and motor control centers.

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2. Feeders and Branch Circuits: Type THWN, 600 Volt insulated, unless otherwise shown.
- a. Minimum No. 12, unless otherwise shown, stranded copper.
 - b. Factory color coded with same color throughout system for same phase. Conform to NEC color code; grounds shall be green, neutrals shall be white. All current or signal carrying wires shall be labeled at both ends; color coding may be used additionally, but is not required. Do not use a white or green wire in a power cable or conduit as a line conductor.
 - c. Bare stranded copper or green colored insulated grounding wire. Buried counterpoise grounding wires shall be bare.
 - d. Minimum No. 10 for all branch circuit runs exceeding 100 feet to the first device or motor.
 - e. No. 14 stranded, red insulated, THWN/THHN control wires for 100 to 600 volt control circuits with self-laminating, wrap-on, numbered labels on each wire; No. 18 minimum with manufacturer's standard color code on 24 volt control circuits and alarm wiring. Home runs from instrument junction boxes shall be multi-conductor, heavy PVC jacketed cables, rated TC or underground burial, with No.14 stranded copper THWN conductors with ICEA "K" color code.
- f. Instrumentation Cables: Except where special cables are required for analyzer probes, computer data, etc., use twisted pair shielded, jacketed instrument cables for all analog signal runs. Cable shall be suitable for conduit, tray and underground use; 600 volt insulation, 105 degrees C rated; with No.16 AWG stranded copper (tinned 7-strand); color coded black and red thermoplastic insulated conductors, 100% foil shielded with No.20 drain wire; black CPE jacketed (low smoke producing); equal to Okonite type "P-OS."
- (1) Multi-pair cables similar to f., above, shall have No.18 AWG conductors, black and red colors, individually shielded twisted pairs, No.22 drain and communication wires, overall black CPE jacket, type TC, equal to Okonite "SP-OS."

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- g. Radio Frequency Cables: Cables from all RF antennas to the respective radios shall be 50 ohms impedance, low-loss foam dielectric coaxial type, 0.5 inches diameter, RG/8U, bare stranded copper center conductor, No.13 AWG and braided bare copper shield with 97% coverage; overall black HDPE jacket. Cable shall be Andrew Corp. No. LDF4-50A, or equal. Confirm this specification with radio supplier.

insulation, T & B, Burndy, Blackburn, or equal.

- F. Control and signal wiring shall terminate on terminal blocks (wire nuts are not acceptable). Use box/plate type as manufactured by Phoenix Contact, Allen-Bradley or Weidmuller. Furnish all accessories such as end plates, track, grounding terminals or devices, surge arresters, etc. Surge arresters shall be included as an integral part of all terminals for field wires and cables coming on or going out of I/O racks and control panels; equal to Phoenix "Termi-TRAB".
- G. Mount all surface mounted enclosures on galvanized structural steel members consisting of pipes and/or channels (11 Ga. minimum thickness) with welded and drilled 1/2" thick base plates standing on concrete (set with approved grout). Provide material weights to suit loads supported. The use of "strut" type channels shall be kept to a minimum, due to the turned back legs which may collect dirt and corrosion. Channels shall be structural shapes unless otherwise indicated.

24.07 CABLE CONNECTORS AND SUPPORTS

- A. Conduit runs shall be positioned to suit field conditions to achieve an unobstructed passage for removal and installation of pumping units and shall provide close accessibility to allow removal of the cable connector by maintenance personnel from outside and above the wet-well.
- B. Cables entering conduit protection and as otherwise noted shall be fitted with connectors sized to suit the cable and conduit actually installed. Connectors shall be plastic body and threaded cap type with neoprene or equal internal gas-tight compression gland.
- C. Cable grips shall be provided as strain relief for cables and shall be wire mesh offset eye, closed mesh type, all fabricated with 304 stainless steel and shall be sized to suit the cable actually installed.
- D. For temperature to 105°C, Interior Wiring, use Ideal Wing Nut or 3M Scotchlok, or equal. For wiring in fixtures 150°C and below, use Ideal Wire Nut, or equal.
- E. For No. 8 and larger, use hand or hydraulic die-press applied compression lugs and sleeves for splices with heat shrink tubing

24.08 INSTALLATIONS

- A. Prior to commencement of work, verify dimensions at site of work. Bring discrepancies or differences to the attention of the Engineer for resolution. Verify limitations of space available for installation clearances of all materials specified herein or indicated on the drawings.
- B. Store materials in secure locations; protect materials from weather and damage prior to installation.
- C. Provide accurate layout, grades and elevations; set sleeves and openings in ample time. Take proper precautions to protect work and equipment from damage. Provide all necessary supports required for the safe and proper installation of all materials and equipment. Install underground conduits, concealed conduits,

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boxes and sleeves in adequate time for other trades to complete concrete pours or other installation work.

- D. 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.
- E. Installation to conform to the applicable paragraphs of NFPA-70 and in accordance with good practice as described in "The Electrician's Handbook", by Croft and Summers.
- F. Install materials and equipment as recommended by the Manufacturer, in addition to the requirements specified herein.
- G. Repair or replace materials damaged during installation. Touch up scratched or marred surfaces.
- H. Raceways: Install rigid galvanized steel raceways and cast galvanized boxes exposed on the surface, on process tanks, along walkways, and below 48 in. high, in electrical and equipment rooms. Cable trays shall be used inside electrical rooms, only; conform to NEC requirements and these specifications for support and minimum size of single conductor wires that may be run in trays. Provide grounding of raceways and trays as specified.
 - 1. During construction, temporarily plug or otherwise protect all installed raceways from the entrance of moisture, dirt, trash, etc. Replace any raceway which may become clogged with dirt, trash, moisture, etc., without additional expense to the Owner. No kinked, clogged or deformed raceway will be permitted on the job. Cut and thread raceways to

proper length so that ends will fit accurately in the outlets; use hubs at sheet steel enclosures. Use hydraulic punches to make knockouts in metal and fiberglass enclosures. Use of hole saws shall be limited to fiberglass and plastic enclosures.

- 2. Properly align, group and support raceways. Install exposed raceways at right angles or parallel to the principal structural members. Firmly fasten raceways in place. Run raceways to avoid trapping wherever possible. Provide necessary inserts in poured concrete areas and furnish and install all necessary sleeves through walls and floors for passage of raceways. Properly seal sleeves through exterior walls of the building. Do not penetrate roof; run conduits to roof mounted fans, etc. inside the limits of the roof curb.
- 3. Rigid Conduit
 - a. Run for all types of wiring, for exterior process and when exposed in buildings.
 - b. Make all joints tight with no running threads; use approved thread sealing compound that will aid in the conductivity of the conduit system and prevent corrosion.
 - c. Ground all conduits using grounding bushings and/or grip tooth type U-bolt clamps with grounding lugs.

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| <p>d. Ream inside edge of cut conduit to prevent wire damage during pulling.</p> <p>e. Coat all field-made threads with two coats of cold galvanizing paint equal to ZRC.</p> <p>4. Make connections to equipment having motors and vibrating devices with plastic jacketed flexible metal conduit, liquid-tight, such as "Seal-tite" flexible metal conduit.</p> <p>5. Hangers and Supports: Rigid Conduit; support all conduits at less than the maximum spacing required by the NEC. Supports of the approved type, Crouse-Hinds, Appleton, Killark, or equal.</p> <p>6. General Installation</p> <p>a. All bends to be factory made or bent with an approved mandrel type bender. Radius not less than minimum permitted by NEC.</p> <p>7. Wire and Conduit Identification: Tag all conductors and identify major conduits in or at wireways, panels, pull boxes, motor controllers, cabinets and similar items to assist in future circuit tracing, at <u>both</u> ends of all wires. Conductor tags to be non-conductive. Identify all circuits and equipment to correspond with the plans and specifications.</p> <p>8. Splices and Terminations</p> <p>a. Feeders shall be spliced <u>only</u> as a last resort. Where required, feeders, sub-feeders and branch circuit conductors, No.8 and larger shall be</p> | <p>spliced with solderless type tin plated copper compression sleeve splices and terminated with compression lugs. Install lugs and splices with a hydraulic powered compression die tool; indenter type tools shall not be used. Use Cadweld method for grounding connections below grade and split-bolt "Servit" studs, or compression lugs and bolts on exposed steel.</p> <p>b. Branch Circuits (Up to No.10): Scotchlok, Ideal, or equal, insulated conical spring type connectors over twisted conductors.</p> <p>c. Instrumentation and control cables shall be terminated at terminal blocks in all cases. Use box-plate type sectional blocks, 6 mm minimum width; tighten terminal block screws with hardened steel high-torque, large-handled screw driver.</p> <p>9. Location of Devices and Outlets</p> <p>a. Prior to roughing-in device and outlet boxes, Contractor shall verify from general construction drawings; all features that will affect the function of the device or outlet. Do not scale the plans; location of devices is shown on plans in desired vicinity. Contractor shall carefully locate devices symmetrically and in</p> |
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| | coordination with structural features. | | grounding conductor No.12, minimum, to all devices and back to panel ground bus. |
| | b. Use isolated ground specification grade receptacles for all computer power outlets. Provide separate equipment and isolated ground conductors all the way from the receptacles to the panel buses. | | b. Install on all conduits using bushing and/or clamps, as required by the Owner and the NEC (NFPA 70). |
| 10. | Pull and Junction Boxes | 12. | Cable Shields: Instrumentation cable shields shall be grounded at the Input/Output rack or RTU end only and insulated on the field end. At all junction boxes and intermediate terminals, keep the shields continuous and isolated from ground, similar to the signal conductors; i.e., use an insulated terminal on the same terminal block (adjacent to the signal pair) for the shield. |
| | a. Provide pull and junction boxes where required by the National Electric Code, whether or not shown on the drawings. | | |
| | b. Identify conductors where more than one circuit passes through a junction box or pull box with electrical characteristics, system designation, source and designation. Provide barriers where required by Code. | I. | If the Contractor finds it desirable to make changes and/or alterations in plans, equipment or materials in order to facilitate construction, he shall submit a proposal for the changes to the Engineer for approval. The Contractor shall not initiate such changes without the Engineer's written approval. No adjustment in quantities or unit prices shall be made for the changes unless attached to the written approval as an authorization for "Change in Work" or "Extra Work." The Contractor, by his acceptance of the approval, agrees not to submit any "Claims for Damage" in connection with the approved changes or alternatives. Design time required by the "Engineer" to facilitate the change will be charged to the Owner and subsequently deducted from the Contractors bid price. |
| | c. Independently support pull boxes on the building or structure. Do not depend on the conduit system for support. | J. | There shall be no mixing of different types of signals within a single conductor, i.e., radio cables or low voltage DC with 120 VAC. |
| | d. Use hydraulic punches to make knock-outs in sheet metal enclosures; hole saws shall be used on non-metallic enclosures only. | K. | Initial calibrations with documentation shall be required for all hardware being |
| 11. | Equipment Grounding Conductors | | |
| | a. All receptacle and lighting circuits shall have a continuous | | |

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installed under this Contract and shall be the responsibility of the Contractor.

- L. All trenching, excavation and meter pits required for proper installation shall be performed or supplied by the Contractor under the Owner's supervision.
- M. Tape and Control Wire Markers:
 - 1. Tape shall be Scotch 33+, or approved equal. Fill voids with rubber tape or filling compound equal to Scotchfil.
 - 2. Use colored Scotch 33 colored plastic tape for color coding phase wires.
 - 3. Use Brady or equal by T & B wire number markers, self-laminating type, for all control wires at both ends. Use an indelible marker pen, typewriter, or label printer to apply number to labels prior to wrapping on the wires.

24.09 IDENTIFICATION AND LABELING

- A. Label all Electrical Junction boxes and equipment with 1-inch high laminated plastic labels with engraved lettering, white letters on black, 3/16 inch high. On main junction boxes, use 2 inch high laminated engraved labels with 1/2 inch high lettering.
- B. Show type of system and voltage of contained wires outside and inside of all junction box covers using 3/4 inch high "Dymo" embossed labels.

24.10 WARRANTY

- A. The Contractor warrants that there are no defects of material or workmanship in the goods described herein. This warranty shall bind the Contractor for a period of two (2) years beyond the date of acceptance. If within such warranty period it is established that any material or workmanship in the goods was defective,

the Contractor shall, at its option, either repair or replace defective materials or workmanship, in either case F.O.B. from its factory. The purchaser agrees that the Contractor's liability under the foregoing warranty shall be limited as stated and that there are no other warranties which extend beyond the description of the face hereof, and that except as stated, the Contractor shall not be liable for any loss, damage or expense; and that in no event shall the seller be liable for any loss of profits or other consequential damages.

No allowance will be made for repairs or replacements not authorized by the Contractor; such allowances will be credited to the purchaser only after he has returned to the Contractor the material which is claimed to be defective. The warranty will provide a two-year limited warranty from date of installation.

- B. This limited warranty does not cover repair of components damaged by abuse, accident, lightning, disaster or misuse.

24.11 MAINTENANCE

- A. All suppliers submitting proposals must have available at least one (1) factory parts and service center. This center shall be staffed with full-time technical as well as order and shipping personnel during regular business hours and days. This factory center must have a toll-free telephone service or agree to accept all calls from Owner.
- B. Maintenance service shall be available from the system supplier either by a maintenance contract or on a per-call basis. The service representative (Contractor) shall also maintain an inventory of replacement modules and major components for quick service for the Owner.
- C. If the manufacturer's service center is unable to repair and have ready to return any I/O cards in the system within 48 hours of receipt from the Owner, the service centers shall have available a rental

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or loaner component for immediate shipment.

24.12 FINAL ACCEPTANCE

- A. After the systems, equipment and fixtures are completely installed, and at such time as the Owner shall direct, conduct an operating test for approval and acceptance by the Owner. Perform the test in the presence of the Owner or his authorized representative. Advance approval of equipment or materials will not constitute a waiver of the requirements that the equipment, fixtures or materials be demonstrated to operate in accordance with these specifications.

** END OF SECTION **