Electrical Engineering Design Guide

• Introduction

The Appendix “A” defines the scope of A&E services. This Electrical Engineering Design Guide further defines the electrical engineering services identified in the Appendix “A” and identifies our technical and submittal requirements for electrical engineers doing work for the Atlantic Division. The information provided in this document is not intended to cover every situation, but is to be followed where applicable. Situations not covered by this document should be approached with sound technical judgment, common sense, and with the intent of this document in mind.

• Communications

Direct communication with the electrical reviewer is encouraged. If you have a question concerning a particular comment, contact your reviewer. This may avoid unnecessary re-submittal of plans and specifications due to a misunderstood comment. The reviewer’s name, phone number and email address can be found on the comment sheets.

• Electrical Engineering Design Requirements

• Multiple Conduit/Cable Runs

To avoid misinterpretation as to the quantity of cables and conduit required in multiple conduit and cable runs, use one of the following acceptable descriptions:

Acceptable:	Two 3 1/2” conduits, each containing four – 500 kcmil and one - #2 Gnd
Acceptable:	Two 3 1/2” conduits, each with four – 500 kcmil and one - #2 Gnd
Acceptable:	Two 3 1/2” conduits, with four – 500 kcmil and one - #2 Gnd in each conduit
Unacceptable:	Two sets of fuor – 500 kcmil and one - #2 Gnd in 3 1/2” conduit
Unacceptable:	Parallel Service: four – 500 kcmil and one - #2 Gnd in 3 1/2” conduit

• Removal or Replacement of Equipment Containing Dielectric Fluid

Determine the PCB content of each item of electrical equipment. If the equipment is labeled PCB filled, or not labeled at all, then it shall be assumed to contain PCBs and the following steps shall be taken:

- Identify and request in writing that the activity test a sample of dielectric fluid for each piece of equipment in question. Do <u>not</u> test fluorescent lamp ballasts; testing is more expensive than disposal. Dispose of fluorescent lamp ballasts as if they were PCB contaminated unless they are labeled “NON PCB”.

- The test results shall be used to identify the equipment as:

(1) Non-PCB" – contains less than 50 ppm.

(2) "PCB" – contains 50 ppm or greater.

- Capacitors shall be identified as follows:

  (1) Capacitors containing less than 3 pounds of dielectric fluid – not required to be identified.

  (2) Capacitors containing 3 or more pounds of dielectric fluid and made prior to 1978 – "PCB".

  (3) Capacitors containing 3 or more pounds of dielectric fluid and made in 1978 or later – "Non-PCB."

- The contract specifications shall require that PCB equipment, after removal from service, but before being moved from equipment location and regardless of equipment condition, be drained of fluids and that the fluids be containerized. On individual projects, verify with the activity and with Environmental Programs Branch (Code EV2) whether PCB equipment and fluids are to be turned over to Public Works for disposal by the Government or are to be removed and disposed of under the construction contract. See the Environmental Design Guide for additional guidance.

- Special restrictions apply when removing fluorescent or HID lamps that contain mercury. See the Environmental Design Guide for specific guidance.

• Environmental Contracts

- Sealed Bid Environmental Contracts administered by Code CI1 shall demonstrate the same level of electrical design effort as any normal Design-Bid-Build project and shall be in total compliance with this design guide.

- Environmental Contracts administered by Code EV shall demonstrate a complete electrical design from the designated point of connection on the existing electrical distribution system to a main disconnect means at each secondary service. A complete electrical design shall also be required for any building which will ultimately be owned by the government; electrical designs shall include any and all electrical systems not directly related to an environmental system and which will not be removed by the Environmental Contractor. Electrical designs shall provide adequate electrical service for all equipment being provided by the Environmental Contractor and specifically, transformers shall be sized to carry <u>all</u> loads. The electrical design shall be in total compliance with this design guide.

• Removal of Existing Cables

When a project calls for removal of existing cables enclosed in either duct or conduit, these cables should be physically removed and <u>not</u> simply abandoned in place. The associated ducts or conduits, if concealed and not in the way of new construction, may be abandoned in place. Existing direct buried cables would also normally be abandoned in place.

• Modification of or Additions to Existing Electrical Equipment

Existing equipment to be “Modified” or “Added to” must be identified by the manufacturer’s name and other pertinent manufacturer’s identification (e.g., serial number, model number, style, etc.).

- ## Asbestos

Any material (including fireproofing tape in manholes, handholes, and vaults) suspected of containing asbestos shall be tested by a qualified laboratory to determine the asbestos content. See the Environmental Design Guide for additional guidance.

- ## Scheduling and Sequencing Construction Contracts

Frequently, it is required that an activity remain in operation while new equipment is installed and existing equipment is replaced, relocated, modified or connected to new equipment. When either situation exists, general statements, such as stating that the activity will remain in operation during the entire construction period and that the contract work will be accomplished so as to cause the least possible interference with normal operations, do not adequately define the requirements to maintain electrical service during the construction period. The following suggestions are offered:

- Provide a specific and detailed Sequence of Construction to eliminate or minimize interruptions to activity operations. Include the Sequence of Construction with the 100% design submittal.

- Specifically identify required power outages. Each power outage must be defined in terms of advance notification, duration and when outages may be scheduled (e.g., after normal work hours, weekends, etc.). Coordinate power outage requirements with the activity.

- Identify preparations and precautions required of the contractor prior to starting specific phases of work or implementing power outages. For instance, if a specific phase of work will interrupt or restrict operations at the activity, it may be necessary to stipulate that material and equipment required to complete the work be on hand prior to starting the work.

- Specify preliminary operations and testing requirements which may be necessary to ensure that the possibility of interference to activity operations is minimized.

- Specify the contractor’s responsibility to provide temporary power either by means of temporary connections or temporary equipment. If temporary equipment is required, specify the contractor’s responsibility for operation, maintenance and repair, and demonstrated reliability of the equipment provided.

- ## Government Furnished Equipment (GFE)

Projects which include GFE have unique problems which must be given special attention. Specify thoroughly the contractor’s responsibility for GFE. The following suggestions pertaining to GFE are offered:

- Ensure that GFE, including associated auxiliary equipment, is adequately identified in the contract documents.

- Indicate when the equipment will be available and where the equipment is to be picked up by the contractor. Identify transportation requirements for which the contractor is responsible.

- Consider storage requirements for the equipment. If the contractor is to provide storage, specify proper storage requirements.

- Ensure that a complete and accurate data package for GFE is available, and identify the data that will be furnished to the contractor after contract award.

- Require the contractor to verify, by field inspection, documentation provided on items pertaining to GFE which might have a significant impact on the installation of GFE or on contractor provided equipment. For instance, if the contractor is providing an automatic control switchboard for a Government furnished diesel generator, the contractor should be required to verify the controls on the diesel generator which must be coordinated for proper interface with the switchboard.

- Require the contractor to coordinate GFE with contractor provided equipment. Include a requirement for the contractor to provide an interconnecting wiring diagram showing connections between the GFE and contractor provided equipment. The interconnecting wiring diagram must be submitted with the contractor's submittal on the contractor provided equipment.

- Identify the contractor's responsibilities for the start-up and testing of GFE. Coordinate this requirement with start-up and testing services included with GFE. Contractor provided start-up and testing must be performed by a qualified person, such as a representative of the manufacturer of GFE.

- Specify the contractor's responsibilities for installing and start-up of GFE. The contractor must accomplish the work normally provided for contractor provided equipment.

• Breaker/Relay Settings

The designer shall discuss proposed relay protection schemes, including selection of relays and current transformer ratios, with Code BE3 during the design process.

The designer shall ensure that construction contract documents require that the contractor submit manufacturer's published time-current curves (on full size logarithmic paper) of primary fuses, relays, main secondary breakers, and secondary feeder protective devices.

Upon completion of successful shop drawing review, the designer shall provide settings for main secondary breakers and secondary feeder protective devices. The designer shall ensure that circuit components are adequately protected against short circuits and ground faults and that protective devices are properly coordinated. Code BE3 will be available to assist the designer if required.

Code BE3 shall be directly responsible for providing settings for protective relays and primary protective devices (except that high side transformer protection for distribution transformers 1500 kVA and smaller shall be selected by the designer). The coordination study shall be done under the same or under a separate contract. Contact Code BE3 for direction. When Code BE3 is responsible for settings, the designer upon completion of successful shop drawing review shall forward all required information to them.

Fuse selections and breaker/relay settings shall be promptly determined and immediately forwarded to Code CI5.

Please note that protective relays associated with Air Force and Army bases are not the responsibility of Code BE3; the designer shall provide settings for these relays and coordinate with the appropriate command.

- **Non-Linear Loads**

Many types of data processing and office equipment, such as computers, copiers, video display terminals, printers, and plotters, use switch-mode power supplies (SMPS). While this technology provides significant reduction in equipment losses, weight, volume, and cost, it also can cause problems in the building electrical distribution system. SMPS draw power from the source in pulses during the peak of each voltage half-cycle, rather than continuously, resulting in severe nonlinearity and high harmonic currents.

When large loads or many small loads of this type are served, the waveshape of the load current is badly distorted and high in harmonics. This results in overheating of neutral conductors, intermittent electrical noise, transformer overheating, and converter failure.

Therefore, when dealing with non-linear loads, it is imperative that the designer obtain accurate load information and precisely design system components based on the load information obtained.

- **Systems Furniture**

Many office spaces are currently being designed utilizing a Systems Furniture approach. Please adhere to the following guidelines when utilizing this approach:

- Thorough coordination between the electrical designer, the architect, and the interior designer is critical during the design process. Systems furniture is typically specified and ordered when construction is nearing completion; therefore, if proper coordination has not occurred during the design process, field interface problems could be very costly.

- Systems Furniture is prewired to a wiring harness. The standard harness configuration is either 5-wire (3 circuit conductors, 1 oversized neutral conductor and 1 equipment grounding conductor) or 8-wire (4 circuit conductors, 1 oversized neutral conductor, 1 full sized neutral conductor and 2 separate equipment grounding conductors). Typically, a 5-wire harness is adequate for up to 9 cubicles and an 8-wire harness is adequate for up to 12 cubicles. Serve 5-wire harnesses with 3 separate circuits; connect each circuit to a different phase and balance loads between phases. Serve 8-wire harnesses with 4 separate circuits; balance loads between both circuits and phases.

- A single circuit should serve no more than three cubicles (computer stations).

- Provide a junction box detail showing the interface between the Systems Furniture wiring harness and the branch circuit wiring.

- Consider using K-rated transformers and panelboards with 200% neutrals.

- **Hazardous (Classified) Locations**

Define in accordance with NFPA 70, “National Electrical Code.” Clearly show boundaries of hazardous locations on the plans and identify the type of hazard by class, division, and group.

- ## Underground Electrical Systems

  - **Criteria/General Guidance**

    MIL-HDBK-1004/1, “Preliminary Design Considerations,” MIL-HDBK-1004/2A, “Power Distribution Systems,” and NFGS-16303N, “Underground Electrical Work.” For the purposes of this guide, an underground conduit or duct run consisting of a single conduit or duct shall be defined as a conduit run; an underground conduit or duct run consisting of two or more conduits or ducts shall be defined as a ductbank or duct run.

  - **Manholes (MH’S) and Handholes (HH’S)**

    Avoid use of combination power and communication manholes; however, when power and communication duct lines follow the same route, use a common trench and locate power and communication manholes in close proximity to one another. Use manholes for main duct runs and wherever shielded medium-voltage cable is installed. Handholes may be used for airfield lighting circuits, for other nonshielded medium-voltage circuits, and on building laterals for low-voltage and communication lines. Don’t use handholes for splicing multi-pair communication cables or shielded power cables.

    Determine size of power manholes by number of circuits and by voltage ratings and splicing requirements of the cables within. Size manholes to accommodate splices. Minimum size manhole for circuits greater than 15kv shall be 9 feet wide by 12 feet long. See paragraph entitled “Calculations” in the “Design Services” section.

    Size communications manholes for equipment and splices contained, including future projections. Manholes shall accommodate racking of splice closure of largest multi-pair cable while keeping cable bending radii greater than 10 times cable diameter. See paragraph entitled “Calculations” in the “Design Services” section.

    Manholes shall be minimum 6’-6” deep.

  - **Locating Manholes (MH’S) and Handholes (HH’S)**

    Provide MH’s/HH’s where duct lines change direction.

    Provide a MH/HH within 100 feet of every riser pole, pad mounted transformer, or unit substation unless a calculation is provided to justify a greater distance – under no circumstances shall this greater distance exceed 200 feet.

    MH separation on straight runs normally shall not exceed 400 feet. In situations where greater separation is desired and this greater separation is not prohibited by either excessive pulling tension or site requirements, MH separation of up to 600 feet may be permitted. See paragraph entitled “Calculations” in the “Design Services” section.

  - **Ductbanks**

Minimum duct size for power distribution circuits in main duct runs shall be 5 inches and minimum duct size for main runs of telecommunication cables shall be 4 inches, unless otherwise directed.

Provide adequate spare capacity for all ductbanks.

- ## Overhead Distribution Systems

  - **Criteria/General Guidance**

    ANSI C2, "National Electrical Safety Code," MIL-HDBK-1004/1, MIL-HDBK 1004/2A, and UFGS-16301N, "Overhead Transmission & Distribution.

    All new overhead primary distribution systems shall be designed as four wire, multi-grounded systems which are wye connected at the source transformer. A bare system grounded neutral conductor shall be provided throughout the overhead system. All underground extensions to pad-mounted transformers, secondary unit substations, and other primary devices shall connect to the system neutral. The underground extension shall provide a 600 volt insulated system neutral. The underground system neutral shall extend to all transformers, substations, and other primary devices and shall be connected to the grounding system of the load or other device.

    Contact Code BE3 for direction when new extensions from existing three phase, three wire, solidly grounded (at the source transformer) systems are anticipated, or when a new point of service is required to support a project.

  - **Pole Sketches and Conductors**

    Use pole sketches whenever applicable. In situations where an applicable pole sketch has not been developed, provide detail(s) as required. Designer developed details must contain a level of detail equivalent to the pole sketches and include material requirements. Unless another presentation method is proposed to and accepted by Code CI44, with the 35% design submittal, pole sketches with required supplementary details shall be used for pole line construction work. See **Note** in the "Site Plans" paragraphs in the "Drawings" section of "Design Services" for direction in regards to overhead distribution work at MCB Camp Lejeune.

    Use bare all aluminum conductors (AAC), bare all aluminum alloy conductors (AAAC), or bare copper conductors. Do not use aluminum-conductor steel-reinforced (ACSR).

    Standard design criteria for sag & tension shall:

    (1) Limit the initial loaded conductor tension to a maximum of 50% of the conductor rated breaking strength. Lesser tension limits are permissible and may be preferable.

    (2) Provide clearance requirements using final sag values in conformance with the NESC, "National Electrical Safety Code" for the maximum conductor temperature.

    (3) Limit the maximum design tension for any conductor to 4,750 pounds. All clearance values shall be based on the following maximum conductor temperatures:

Copper phase conductors – 167 degrees F.

Aluminum/Aluminum alloy phase conductors – 194 degrees F.

Neutral conductors for all multi-phase circuits – 120 degrees F.

The maximum conductor temperature for single-phase neutral conductors shall be identical to the phase conductors.

- **Fuse Protection**

  Provide backup current limiting fuses for overhead distribution transformers on voltage systems: (a) above 15 kV and (b) on lower voltage systems that have available fault currents equal to or greater than 7,000 asymmetrical amperes.

  The purpose of the backup current limiting fuse is to protect the transformer from high level fault currents that can rupture the transformer tank and result in catastrophic damage. The expulsion fuse link is required for overload and low level fault current protection. The two protective devices must be coordinated to function together; expulsion fuse links should be ANSI Type K to provide this coordination.

  Exercise care when using fused cutouts at line taps and at underground terminations. The maximum interrupting rating of a fused cutout is 12,500 symmetrical amperes. Whenever system fault currents exceed this value, protect the fused cutout with a backup current limiting fuse or use an adequately rated power fuse.

  Specify:

  (1) ANSI Type K fuse links sized as indicated on the drawing.

  (2) Testing of backup current limiting fuse in series with expulsion fuse according to ANSI C37.41, “Design Test for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fused Disconnecting Switches, and Accessories.”

  (3) Backup current limiting fuses manufactured by A.B. Chance Co., Cooper Industries, or an approval equal.

- **Pole Mounted Transformers**

  Use only single phase transformers.

  For single phase installations and when banking single phase transformers for three phase applications, primary connections should be phase-to-neutral - unless connected on three wire distribution systems.

400 Hertz Systems

- **Design Criteria**

  MIL-HDBK-1004/5, “400 Hz Generation and Distribution Systems.”

- **Nominal Utilization Voltage**

  The nominal ac utilization voltage is 208Y/120V, three phase, 4 W.

- **Techniques for Minimizing Voltage Drop**

  (1) Use rigid aluminum or PVC conduit except that aluminum shall not be used in concrete.

  (2) Use only copper conductors.

  (3) Use thin-wall insulation type (THWN, THHN, XHHW, etc., should be considered).

  (4) Use multi-conductor cables.

  (5) Use smaller paralleled conductors in lieu of larger single conductors.

  (6) Use line drop compensators.

- **Isolating 400 HZ Systems**

  The 400 Hz system shall be completely separate from other systems (i.e., a 400 Hz circuit shall not be installed in the same box or cabinet as a 60 Hz circuit unless barriers are used to separate sections).

- **Equipment Rating**

  Circuit breakers, panelboards, etc., shall be rated, calibrated, and labeled by the manufacturer, and indicated on the contract drawings as 400 Hz equipment. However, the manufacturer, at his option, may use 60 Hz equipment if the 60 Hz equipment is properly derated for 400 Hz operation and if the 60 Hz equipment contains the manufacturer's label stating that the equipment has been properly derated and is satisfactory for 400 Hz operation.

• Direct Current (DC) Systems

Provide in accordance with MIL-STD-704, "Aircraft Electric Power Characteristics."

• Telecommunications (Voice and Data) Systems

- **Criteria**

  MIL-HDBK-1012/3, "Telecommunications Premises Distribution Planning, Design, and Estimating."

- **General Design Procedure**

  See Telecommunications Coordination and Responsibility Chart (Attachment 1).

- **Physical Description**

  Cable and Pathway – Provide Category 5 Unshielded Twisted Pair (UTP) copper cable for building backbones not exceeding 295 feet and for horizontal cable runs; provide fiber optic cable for data backbones exceeding 295 feet. Cable pathways shall be conduit and cable tray. Special conditions, user requirements, and economic considerations may warrant exceptions to be taken in regards to the previous two sentences. Size voice backbone cable for one active pair per outlet served plus at least 50 percent spare capacity. Data backbone cable typically runs between LAN

equipment locations and shall have a minimum of four copper pairs or four optic fibers.

Telecommunications Closets and Rooms – Provide telecommunications closets, equipment rooms, and entrance rooms in accordance with MIL-HDBK-1012/3. Provide at least one telecommunications closet on each building floor; additional closets may be required to insure that no horizontal cable run exceeds 295 feet in length. In multi-story buildings, locate telecommunications closets one above the other. Equipment rooms and entrance rooms may be combined with telecommunications closets if there is adequate space for the required equipment. A minimum of two walls in each closet shall be covered with ¾ inch plywood in accordance with MIL-HDBK-1012/3. Cabinets may be used instead of closets in small buildings with 1000 square feet or less of useable space.

Cross-Connects and Entrance Protectors – Provide type 110 cross-connect blocks to terminate copper pairs and provide type SC optical patch panels to terminate fiber optic cable. Do not provide cross-connect jumpers and patch cords. Code CI44 may approve Type 110-to-modular patch panels for Category 5 UTP data systems when special user requirements justify the costs. Provide a building entrance protector assembly to protect all outside cable pairs.

Telecommunications Outlets – Provide workstation telecommunications outlets having a minimum of two RJ-45 ports, one Category 5 voice port and one Category 5 data port. Provide a separate four-pair Category 5 UTP cable to each port from the respective voice or data field of a telecommunications closet cross-connect. Where special conditions require fiber to the outlet, provide type SC connectors. Conduit for single outlets shall be minimum of ¾ inch diameter, for two outlets minimum of one inch, and for three outlets minimum of 1 ¼ inches. No more than three outlets shall be on a conduit run.

Power Receptacles – Provide a minimum of two 120 volt, 20-ampere dedicated duplex receptacles in each telecommunications closet. Each dedicated receptacle shall be on a 20-ampere branch circuit serving only that receptacle. Additional convenience receptacles shall be provided at six-foot intervals around the perimeter walls.

Telecommunications Grounding System – Provide a minimum of one copper ground bar in each telecommunications closet, including a main ground bar at the telecommunications service entrance. Interconnect all ground bars with number 6 AWG insulated copper conductor routed with the backbone cable. Connect the main ground bar to the building grounding electrode system, preferably to the ground bus within the electrical service equipment enclosure. Bond ground conductor in conduit to both ends of the conduit. Bond the telecommunications grounding system to any lightning protection system that may be located on the premises per NFPA 780, “Lightning Protection Code”.

- **Emergency Lights, Exit Lights, and Fire Protection Systems**

Provide power for emergency lights, exit lights, and fire protection systems in the following manner:

- Provide unit equipment (equipment with self-contained rechargeable battery, battery charging means, and automatic transfer to and from battery) for emergency lights, exit lights, and fire protection systems. Specify LED type exit lights unless specifically instructed otherwise.

- The branch circuit feeding the emergency lights and exit lights shall be the same branch circuit as that serving the normal lighting in the area and connected ahead of any local switches.

- Provide power for the fire protection systems from the MDP.

  (1) 208Y/120 V or 120/240V system
  Provide lock-on breaker in the MDP.
  If more than one fire protection circuit is required, provide a dedicated emergency panel (sized for a minimum of six circuits) powered from the lock-on breaker in the MDP.

  (2) 480Y/277 V systems
  Provide circuit from the MDP (as above) to a dedicated emergency panel through a step-down transformer. Consider using a packaged power supply for this transformer/emergency panel combination. Size the emergency panel for a minimum of six circuits.

  (3) Locate the dedicated emergency panel near the MDP where practical.

  (4) In all cases paint the lock-on breaker in the MDP and the dedicated emergency panel enclosure red. At the MDP, in addition to the panel nameplate, provide a label with the following inscription: "Emergency Breaker Within." Label shall be constructed and fastened identical to the panel nameplate, except the label shall be red laminated plastic with white center core.

- If significant amounts of emergency power are required for loads other than lighting and fire protection systems, provide a second source of emergency power in accordance with NFPA 70, Article 700.

- For systems that require emergency power sources, such as generators or uninterruptible power systems (UPS), these sources may be incorporated into the design.

- Electrical service to fire pump(s) shall be in accordance with NFPA 70, Article 695.

Grounding Systems

Proper grounding is essential both for safety and for the correct operation of sophisticated systems. Provide grounding systems in accordance with NFPA 70, ANSI C2, MIL-HDBK-419A "Grounding, Bonding, and Shielding for Electronic Equipment and Facilities; "MIL-HDBK-1012/1, "Electronic Facilities Engineering; "NAVSEA OP-5, "Ammunition and Explosives Ashore;" and other criteria as applicable. Provide a Grounding Diagram similar to those depicted on Attachments 29 through 31.

Medium-Voltage Cable

Description

Provide the following minimum information:

- Conductor size

- Number of conductors (e.g., 3-1/c, 1-3/c, etc.)
- Insulation voltage rating (e.g., 5 kV, 15 kV, etc.)
- Insulation type

- **Insulation Type**

  Provide ethylene propylene rubber (EPR) for new cable. Paper insulated lead covered (PILC) should be used only where special conditions justify.

- **Cable Shields**

  Use tape shielded cables and ensure minimum bending radii of 12 times the overall cable diameter; use wire shielded cables (see NEMA WC 8, "Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy," for minimum cable bending radii) only where existing manholes are utilized and the minimum cable bending radii of tape shielded cables cannot be realized. Please note that the minimum cable bending radii refers to the inner surface of the cable and not to the axis of the cable.

- **Number of Conductors**

  Use 1/c cable as a general rule; 3/c cable may be used when special conditions justify its use.

- **Existing Conditions**

  Ensure that new cables and specified splicing methods are compatible with existing cables. Provide the same information (e.g., insulation type, insulation rating, conductor type, and number of conductors) for existing cables as required for new cables. Caution: Existing cable may be fireproofed with asbestos in manholes. Refer to paragraph entitled "Asbestos", herein.

• Pad-Mounted Transformers

Use pad-mounted transformers (properly protected with bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses) for kVA ratings up to and including 750 kVA on 5 kV systems and for kVA ratings up to and including 1500 kVA on 15 and 25 kV systems.

Primary connectors and switches are not currently available for 34.5 kV, 200 kV BIL systems; therefore, for these systems, use either secondary unit substations or pad-mounted transformers, separately protected with vacuum fault interrupter equipped switches.

The 200A load-break separable insulated connector normally specified for use on dead-front pad-mounted transformers will accommodate a maximum cable size of No. 4/0 AWG and has a fault-closure current rating of 10,000 amperes and a short-time current rating of 10,000 amperes for 0.17 seconds. On systems which require a primary cable larger than No. 4/0 AWG or which require a short-time rating in excess of 10,000 amperes, a 600A separable insulated connector would be the preferred alternative. The 600A connector is dead-break and has a short-time current rating of 25,000 amperes for 0.17 seconds. The 600A connector is physically larger than the 200A connector and may require a deeper

transformer compartment; UFGS-16272N, "Three-Phase Pad-Mounted Transformers", which is based on 200A connectors, will require significant modifications. Live-front pad-mounted transformers or secondary unit substations may also be alternatives.

The Load Break Oil Switches (LBOR's) normally specified for use as inherent equipment on pad-mounted transformers are available with a maximum make and latch rating of 10,000 RMS amperes symmetrical. In locations with fault currents in excess of 10,000 amperes the internal LBOR switch should be deleted from the specification and details. Provide a separate external switch which meets the required ratings.

A 38KV, 300 ampere LBOR switch is available with a 12,000 RMS ampere symmetrical rating. If used, the specification for the LBOR needs to be edited to incorporate all the 38KV switch ratings.

Portions of the 4.16KV system at Dam Neck and all of the 11.5KV system at Norfolk Naval Shipyard have fault current in excess of 10,000 RMS amperes symmetrical. The designer shall check with Code BE3 to obtain the available fault duty of the system in question.

The use of pad-mounted transformers with secondary currents exceeding 2000 amperes is discouraged due to the size and quantity of secondary conductors; therefore, transformers above 750 kVA serving 208Y/120 volt loads and transformers above 1500 kVA serving 480Y/277 volt loads should be in a secondary unit substation configuration.

When using a pad-mounted transformer, select the applicable pad-mounted transformer detail from Attachments 2 through 5, supply the missing data, and incorporate that detail onto the contract drawings.

Attachments 2 through 4 depict three phase radial feed units utilizing "dead front construction" which is a typical design application. In rare cases when "live front construction" is required due to equipment ratings (available system fault current values), the contract documents shall be modified accordingly. Likewise, when single-phase pad-mounted transformers are required, appropriate contract specific details shall be provided. Do not use the pad-mounted transformer details to depict secondary unit substations.

- **Location**

  Transformer location with respect to buildings shall meet requirements of MIL-HDBK-1008C "Fire Protection for Facilities Engineering Design and Construction" and NFPA 70.

- **Description**

  Use IEEE STD. C57.12.00 "General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers" designation of voltage ratings (example: 11.5 kV – 208Y/120 volt).

- **Surge Protection**

  The following guidelines shall be used for arrester installation within pad-mounted transformers:

  - For systems less than 5 kV, do not provide surge arresters in pad-mounted transformers.

- For systems greater than 5 kV but less than 15 kV, provide surge arresters within the transformer if the transformer is located at the end of the primary circuit. If the transformer is loop feed with the circuit extending beyond the transformer, do not provide surge arresters.

- For systems greater than 15 kV, provide surge arresters in all transformers.

- **Regulators**

  Provide the following information:

  - KVA
  - Line current at full regulation
  - Voltage
  - Phase
  - Regulator type (e.g., step-voltage, induction, etc.)
  - Style (e.g., station type, distribution, etc.)
  - Insulation type (e.g., oil, etc,)
  - BIL
  - Temperature rise
  - Percent regulation
  - Number and percent steps (e.g., 32-5/8% steps)
  - Line drop compensation
  - Special features as needed

  Provide bypass and disconnect switches with regulators.

- **Capacitors**

  Fuse or otherwise protect capacitors to prevent case rupture. Provide the fuse (or other protective device) curve plotted against the case rupture curve on full size logarithmic paper. Also show the full load and fault currents for a faulted capacitor unit on the same sheet.

  Connect capacitors ungrounded wye, unless otherwise instructed.

  Provide the following information:

  - Capacitor type (e.g., outdoor, etc.)
  - Mounting (e.g., rack mounted, etc.)

- KVAR per unit
- Number of units per bank
- Voltage (voltage rating of units, not the system voltage)
- Phase (e.g., three-phase or single-phase units)
- Fuse size and type

- **Surge Arresters and Fused Cutouts**

  Provide the following information:

  - Arrester kV rating
  - Cutout kV and ampere rating
  - Fuse link type and ampere rating

  Provide surge arresters on the line side of:

  - Pole mounted transformers
  - Overhead to underground terminal poles
  - All "normally open" switch ways of pad-mounted sectionalizing switches connected to and served from overhead lines
  - All primary metering installations connected to and served from overhead lines

  Provide surge arresters on the line and load sides of:

  - Gang operated airbreak switches on overhead lines
  - Primary metering applications on overhead lines
  - Recloser/Sectionalizer applications on overhead lines

- **Watt-Hour Meters**

  Provide watt-hour meters with 15-minute interval sweep-hand type kW demand register for all buildings, except housing units.

  Supply housing units with meter sockets only. Sockets shall be single phase, four terminal, ringless with manual bypass device and polycarbonate blank cover plate.

  Place meters and meter sockets in accessible locations.

- **PT'S and CT'S**

  Carefully coordinate connection and ratio of potential transformers with relay and meter requirements.

Provide separate current transformers for relaying and metering. Metering current transformers shall be single ratio.

- **Instrumentation**

  Thoroughly identify requirements.

- **Relaying**

  Provide the following minimum information:

  - Function (overcurrent, voltage, differential, etc.) using ANSI designation numbers.
  - Quantity.

- **Switchgear**

  Provide batteries for dc tripping of circuit breakers. Do not use direct trip, ac trip, or capacitor trip.

- **Switchboards**

  Fusible switchboards may be used only if such use is justified.

- **Panelboards**

  As a general rule, provide one spare circuit for each five active circuits in a panelboard to allow for future load growth. Spare circuit capacity may consist of spare breakers or a combination of spare breakers and spaces at the designer's discretion.

  When spare circuit capacity is provided in flush-mounted panelboards, also provide additional conduit capacity to avoid tearing out of walls. The additional conduit capacity may consist of empty conduit runs to covered boxes above the ceiling or beneath the floor, oversizing conduits in active circuits, or by other means that may seem appropriate to the designer.

  Number circuits by pole number on single pole breakers and by first pole number on two and three pole breakers.

  Indicate load in amperes, not kW or kVA.

  Do not use fusible panelboards.

  When more than 42 poles are required, provide separate panelboards. Do not use dual section panelboards.

  Panelboard circuit breakers shall be fully rated for the available system fault duty. Series rated circuit breakers are unacceptable.

- **Lighting**

  - **Design Criteria**

MIL-HDBK-1004/4; MIL-HDBK-1190, "Facility Planning and Design Guide"; MIL-HDBK-1013/1A, "Physical Security of Fixed Facilities"; and OPNAVINST 5530.14, "Physical Security and Loss Prevention."

- **General Guidelines**

  Provide illumination levels consistent with MIL-HDBK-1190 recommendations and with customer needs. Design to conserve energy, but provide a pleasant and comfortable work environment.

  Utilize such techniques as the following to obtain a balance between energy conservation and customer needs:

  - Multiple switching of fixture groups to permit lights to be turned off in unoccupied workstations
  - Multilevel switching
  - Time switch and/or photoelectric control of outdoor lighting
  - More efficient lighting sources, fixtures, and lamps
  - Grid-type ceilings with the capability of interchanging relocatable panels and lighting fixtures without rewiring
  - Occupancy sensors
  - Daylighting sensors and controls

- **Fixture Considerations**

  Provide energy efficient fluorescent lamps and energy saving ballasts.

  Be selective in the use of Circline lamps, as their cost is greater than other fluorescent light sources. Typically, compact fluorescent lamps would be the more appropriate choice.

  Minimize fixture types and lamp types to reduce maintenance inventories.
  Provide fixture which is appropriate for the intended application.

  When designing exterior lighting systems, consider glare, cutoff, and light trepass.

- **Exterior Sports Illumination**

  Unless specifically directed otherwise, outdoor sports lighting shall conform to the classifications stated in the IES Lighting Handbooks as indicated below:

Sport	IES Classification
Baseball	Municipal and Semi-Professional
Softball	Industrial League
Football	Class III or IV
Other	Recreational

- ## HVAC Equipment

  - **General Guidelines**

    The mechanical engineer will determine which equipment will have integral magnetic contactors and/or disconnect switches and which equipment will require separate magnetic motor controllers and disconnect switches. In general, packaged refrigeration equipment has integral magnetic contactors and in some instances will have an integral disconnect switch also. Air-handling units and pumps usually require separate magnetic motor controllers and disconnect switches.

    The electrical engineer, in conjunction with the mechanical engineer, will determine the location of separate magnetic motor controllers and disconnect switches. Magnetic motor controllers and disconnects shall be placed in readily accessible locations (as defined by NFPA 70).

    The electrical engineer will not provide any magnetic motor controller information for mechanical equipment on the electrical drawings, but will determine the type of controller required (full voltage, reduced voltage, reversing, multi-speed, NEMA size, and NEMA enclosure type) and furnish same to the mechanical engineer for incorporation in mechanical equipment schedules. Mechanical equipment schedules will also include electrical characteristics of motor and packaged equipment; e.g., voltage, full load amperes or minimum circuit amperes, number of phases, horsepower, and frequency. Integral disconnects, if provided, shall be noted in the mechanical equipment schedules and coordinated with the electrical drawings. Require integral disconnects be furnished with thermal overloads where appropriate for small fractional horsepower motors. The mechanical specifications must be coordinated with the mechanical equipment schedules and mechanical plans.

  - **Unit Heaters**

    Electrical unit heaters will be sized and located by the mechanical engineer, will be shown on the electrical drawings, noted and properly cross-referenced on the mechanical drawings, and specified in the mechanical specifications.

  - **Other Equipment**

    The electrical engineer must be alert for motors required for equipment furnished by other than mechanical engineers such as motorized doors, elevators, pumps, cranes, etc.

- ## Motor ratings

  Motor ratings shall be rated in Horsepower on both English and Metric projects. Indicated horsepower ratings shall be standard horsepower ratings in accordance with NEMA MG-1 and the National Electrical Code. On Metric projects, Mechanical Equipment Schedules shall indicate ratings in kW output with the corresponding standard horsepower rating shown in parenthesis. Conversion factor from standard motor horsepower ratings to kW ratings shall be 0.746.

- ## Motor Control Equipment

- **Equipment Selections**

  The choice between using motor control centers (MCC's), motor starter panels, combination starters, and individual starters and disconnects must be evaluated. Several points for consideration are:

  - Centralized control location necessary or required.
  - Quantity of motors and equipment to be controlled.
  - Sizes of motors and equipment.
  - Economic considerations (price comparisons)

- **Selection Guidance**

  (1) Individual motor starters and disconnects are preferred over combination starters and are usually more cost effective.

  (2) Individual motor starters and disconnects are usually preferred and are more economical than MCC's and motor starter panels, especially where small motors and scattered loads are involved.

  (3) Motor starter panels would be preferred over MCC's where a centralized control location is required, where NEMA Size 0 starters can be used, or where a wall mounted versus floor mounted equipment panel is desirable.

  (4) MCC's would be used where a centralized location is required and where the quantity of equipment and/or the starter sizes (NEMA Size 1 and larger) would justify the additional expense.

• Lightning Protection

Provide in accordance with MIL-HDBK-1004/6, "Lightning Protection."

• Cathodic Protection

Provide in accordance with MIL-HDBK-1004/10, "Electrical Engineering Cathodic Protection." System design shall include the following:

- Location of all existing and new rectifiers, anode beds, structures protected by cathodic protection system(s) and all structures which may be affected by stray current corrosion as a result of cathodic protection of the specific structure within the affected area of cathodic protection.

- Test stations along the route of pipelines for structure-to-electrolyte testing of pipelines. Include test stations every 1000 feet along paved route of pipelines. Include permanent reference electrodes, i.e., copper-copper sulfate, at test stations for periodic monitoring of system.

- Include independent permanent reference electrodes, i.e., copper-copper sulfate, not associated with automatic potential control circuits, at various locations below mean low water level for independent monitoring of system. Provide test access handholes around the roof circumference of on-ground water storage tanks for structure-to-electrolyte testing of structure and provide a minimum of two reference electrodes in

the tank. Provide a minimum of three reference electrodes in the bowl and two reference electrodes in the riser of elevated water storage tanks.

- Obtain soil resistivity data for the specific site of the structure under protection and for the location of anode beds. Utilize the 4-pin method for soil resistivity measurement and provide all readings with the design calculations. Historical soil resistivity data may be obtained from the Corrosion Program Coordinator, Mr. Dave Jutton, Code BE14, at (757)322-4650.

- **Intrusion Detection Systems (IDS)**

  Provide in accordance with DM-13.02. "Commercial Intrusion Detection System (IDS)."

- **Uninterruptible Power Systems (UPS)**

  Provide in accordance with MIL-HDBK-1004/1 and MIL-HDBK-1012/1.

- **Instrumentation and Controls**

  See the "Instrumentation and Controls" paragraphs in the "Basis of Design" section of "Design Services".

- **High Altitude Electromagnetic Pulse Protection (HEMP)**

  Provide in accordance with MIL-HDBK-423, "High-Altitude Electromagnetic Pulse (HEMP) Protection for Fixed and Transportable Ground-Based Facilities" (draft) and MIL-STD-188-125, "High-Altitude Electromagnetic Pulse (HEMP) Protection for Ground-Based C^4I Facilities Performing Critical, Time-Urgent Missions."

- **Ordnance Facilities**

  Provide in accordance with NAVSEA OP-5.

- **Automatic Standby Power Systems**

  The Electrical Engineering Branch (Code CI44) will typically design systems involving multiple units with complex parallel and synchronization schemes.

- **Cable Television (CATV) Systems**

  Unless directed otherwise, provide a complete system to be owned and maintained by the government. System shall be designed in accordance with BICSI, "Building Industry Consulting Service International", NFPA 70, "National Electrical Code", and shall be coordinated with the local CATV service provider.

  (For CATV systems at Camp Lejeune run a 3/4" conduit with pull wire from each room desiring cable TV to the telephone room. In the room, provide an outlet box with cover with an F-type connector. In the telephone room, provide a plywood backboard for future use. From the telephone room, provide a 3" conduit with pull wire to the outside of building. If possible, terminate the conduit beside an existing power pole. Af all utilities are designed to be located in duct banks, provide a duct for CATV in the new telephone manholes.)

• Design Services

• Electrical Basis of Design

• Interior Distribution Systems

Electrical Characteristics - Describe the electrical system to be provided and justify its selection. Indicate voltage, phase, and number of conductors.

Estimated Electrical Loads - Provide a breakdown, by category, of the estimated connected loads, demand factors, and demand loads for each category, total demand load, diversity factor, and total diversified demand load. Load categories shall include lighting, convenience outlet, mechanical equipment, special operating equipment, user equipment, and miscellaneous. Include 25% for future growth on new service equipment.

Wiring Methods - Indicate the type of wiring method, such as rigid conduit, electrical metallic tubing, cable tray, nonmetallic sheathed cable, etc., and where proposed to use.

Conductors - Indicate the type of conductors and insulation material such as CU, AL, THW, XHHW, etc., and where proposed to use.

Standards of Design - Describe the proposed standards of design, such as voltage drop, illuminance values, type of light sources, and , if applicable, a statement regarding the use of selective switching or other energy conserving features.

Special Systems - Describe the proposed type of systems. Indicate each system's function and the interrelationships between systems, when applicable. Identify government-furnished equipment, if any. Special systems include such systems as Cable Television (CATV), Closed Circuit Television (CCTV), Intercom, Sound, Nurse Call, Security, Uninterruptible Power Supplies (UPS), etc.. Identify special security requirements, such as Tempest, Red/Black criteria, etc.. Identify special physical security requirements.

Telecommunications Systems - Describe system/systems to be used. Identify space required for telecommunication equipment, and size of incoming duct/conduit. Include statement relative to interface provision for multi-use systems (i.e., intercom, voice, data, etc.).

• Exterior Distribution Systems

Existing Primary Power Source - Identify the location of the point of connection into the existing primary system. Address the characteristics of this primary system, including voltage, phase, number of conductors, available fault current, and voltage regulation. Address the adequacy of the primary system; if inadequate, state measures proposed to correct the inadequacy.

Estimated Electrical Project Load - Provide an estimate of total connected load and the resulting kilowatt demand load. Apply proper demand and diversity factors if a group of loads is involved.

Voltage Selection - Provide basis for selection of primary and/or secondary voltages.

Conductors - Indicate conductor material and where it is proposed to be used. Indicate type of insulation on cable systems.

Standards of Design - Describe pertinent standards of design, such as voltage drop, equipment ratings, types of luminaires and illuminance values.

Special Systems - Identify any special systems, such as Intrusion Detection Systems (IDS) or Cable Television (CATV).

Telecommunications System - Identify point of connection into base telephone system. Describe modifications, if required, to existing base telephone system.

- **Instrumentation and Controls**

  Overall Process - Provide a general description of the overall process to be controlled and a general description of the system operation, including both automatic sequencing and manually initiated control.

  Control and Monitoring Equipment - Provide a general description of the equipment to be used to control and monitor the process (i.e., PC, PLC, local I/O, distributed I/O, drives, etc.) and the basis for selection.

  Protocols - Provide a general description of the protocols to be used to communicate between the control and monitoring equipment and the control and sensing devices (i.e., serial, RTU, LAN, Ethernet) and the basis for selection.

  Transmitting Equipment - Provide a general description of the equipment to be used to transmit data to/from remote stations (i.e., radio, tone/telemetry, etc.) and the basis for selection.

  Operator Interface Devices - Provide a general description of the operator interface devices to be used (i.e., PC's, display stations, data panels, terminal displays, message displays, etc.).

  Interface Software - Provide a general description of the PC and programmable operator interface software features and development (i.e., graphics, controls, alarms, trending, data logging, charts, etc.).

- ## Electrical Calculations

The designer is responsible for calculations to verify proper design and operation of the facility to the point of connection to the existing electrical systems.

Assumptions and given data shall be clearly provided. Calculations shall be described fully and shall be written clearly.

Computer printouts are acceptable only if accompanied by explanations to allow adequate review of calculation methods and results.

Whenever the sizing of electrical transformers, breakers, electric cables, etc., is to be performed, provide calculations to verify proper facility design. The following calculations are usually required:

(1) Short Circuit: Provide an impedance diagram with calculated fault and impedance values. Refer to IEEE STD 399, "IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis." For transformers larger than 1000 kVA in

size, the primary or source impedance shall not be assumed to be equal to 0; source impedance in such situations shall be requested from Code BE3.

(2) Voltage Drop: Quote applicable source for this calculation.

(3) Lighting: Interior and Exterior.

(4) Load Analysis: Indicate connected load and demand load utilizing appropriate diversity and demand factors. Include 25% for future growth.

(5) Motor Starting/Flicker Analysis: For motors 50 hp and greater.

(6) Sag, Tension, and Guying Analysis: For overhead distribution systems.

(7) Manhole Design Calculations: Provide calculations verifying that selected manhole size is adequate for training and splicing of contained cables.

(8) Cable Pulling Tension Calculations: For straight duct runs exceeding 400 feet in length and for any duct run with sweeps or multiple bends.

(9) Cathodic Protection Calculations: Provide calculation for all designs. Include environmental resistivities and justify all assumptions.

(10) CATV Network Loss Calculations: Provide in accordance with BICSI.

- ## Electrical Drawings

  - **General**

    Provide adequate plans, including demolition, existing conditions, and new work, legends, details, diagrams, etc., to clearly define the work to be accomplished. Provide a General Note at the beginning of the Electrical Drawings clarifying the work to be accomplished. The following note is recommended for most jobs:
    "ALL ELECTRICAL WORK AND MATERIAL IS NEW AND SHALL BE PROVIDED BY THE CONTRACTOR UNLESS INDICATED OTHERWISE".

  - **Arrangement**

    Electrical Drawings shall be arranged in the following order:

    - Legends and Abbreviations
    - Site Plan(s)
    - Demolition Plan(s)
    - Lighting Plan(s)
    - Power and Communications Plan(s)
    - Grounding Plan
    - Roof Plan
    - Lightning Protection Plan
    - One-Line/Riser Diagrams
    - Schedules and Elevations
    - Details/Diagrams
    - Lighting Fixture Sketches
    - Pole Sketches

- **Presentation**

  Drawings shall be clear and consistent in presentation and format.

  The following NEMA Metric conversions for conduit shall be followed:

English	Metric
½"	16 mm
¾"	21 mm
1"	27 mm
1 ¼"	35 mm
1 ½"	41 mm
2"	53 mm
2 ½"	63 mm
3"	78 mm
3 ½"	91 mm
4"	103 mm
5"	129 mm
6"	155 mm

- **Legends and Abbreviations**

  Use multiple legends where required; carefully identify the specific use of each legend. Avoid using composite legends which include all symbols but fail to indicate which symbols are to be used where. See Attachments 6 through 22 for standard legends and abbreviations.

- **Site Plans**

  Electrical Site Plans shall be separate and distinct from other utility site plans and shall be included with the electrical drawings. However, when project requires only minor utility work, electrical and civil site plans may be combined. Coordinate with the electrical engineering reviewer before combining the electrical and civil site plans. Demolition and New Work should normally be shown on the same site plans. Indicate the beginning and ending points of utility removals.

  The orientation of electrical drawings shall be consistent with the civil drawings. In addition, the orientation of partial building or site plans shall be identical to the orientation of the larger plan from which the partial was taken. When cross-referencing sheets, each reference to a detail, partial plan, etc., shall indicate the exact title of that particular detail, partial plan etc.

  For overhead distribution use a separate symbol for each individual circuit; define each circuit by voltage level as well as number, size and type of conductors. Coordinate guying and conductor sag information shown on the drawings with that shown in the specifications.

  When in doubt as how to show overhead distribution work carefully review the information contained on Sketches OH-1.1 through OH-1.5a. Do not describe proposed work by referencing sketch numbers instead of pole detail designation symbols.

  Do not use pole detail designation symbols to describe existing facilities to be removed.

When using poles sketches, a note referencing the pole detail designation symbols (similar to the following) must be placed on the drawings:
"XFB, 15FR3-N, etc., are pole detail designation symbols. Refer to Sketches OH-1.1 through OH-41 on Sheets _____ for an explanation of the use and description of equipment provided by these symbols."

Do not modify pole sketches; any required exceptions or modifications must be included as supplemental information with the pole detail designation symbols.

Note: The above comments concerning the use of pole sketches do not apply for overhead electrical distribution designs at MCB Camp Lejeune. Contact Public Works Design Branch in Building 1005 (Tel: 910-451-3658) at Camp Lejeune for direction on each design project. In general, overhead systems at Camp Lejeune shall be designed using "armless construction" instead of "crossarm construction" as described by pole sketches.

Indicate conductor initial sag values. Provide initial sag values at ambient temperatures in 15°F increments for a temperature range, which includes the outside summer and winter design temperature values. Refer to Note (a) of Table 2 in the Mechanical Engineering Design Guide for the required design temperature values. Clearly indicate each different calculated ruling span on the plans and provide initial sag for one span in the calculated ruling span.

Provide appropriate detail indicating the use of backup current limiting fuses with the device being protected. Use the appropriate transformer symbol for current limiting fuses when using the poles sketches. Indicate the ampere rating of the ANSI Type K expulsion fuse link as well as the voltage rating and current designation of the backup current limiting fuse.

Locate Pad-Mounted Transformers with respect to buildings in accordance with MIL-HDBK-1008C, "Fire Protection for Facilities Engineering Design and Construction" and NFPA 70.

Provide the following transformer descriptive information:
- transformer type (e.g., pad-mounted, pole mounted, station type, unit-substation, etc.)
- kVA
- phase (e.g., single or three phase)
- IEEE STD. C57.12.00 "General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers" designation of voltage ratings (e.g., 11.5KV – 208Y/120 volt)
- primary and secondary connection (when using single-phase units for three-phase service; specifically indicate how the units are to be connected, i.e., connect delta-wye grounded for 208Y/120 volt secondary service)

Include the following information about surge arresters and fused cutouts: arrester kV rating, cutout kV and ampere rating, fuse link type and ampere rating.

Profiles may be required for ductbank runs. Discuss profile requirements with the electrical reviewer. Indicate structure (manhole and handhole) tops, ductbank elevations, slopes and diameters. Coordinate structure numbers with plan sheets. Show and label all crossing utility lines, both existing and new. If depths of existing utilities are unknown, indicate the horizontal location of the utility and indicate the vertical location with a line representing the anticipated range of elevations where the

utility will be found in the field. Indicate the method of new utility installation routing above or below conflicts.

Provide a cable/ductbank schedule indicating cable identification, description, conduit size and remarks.

Provide manhole exploded views for all multiple-circuit primary systems and all primary systems requiring splices.

- **Demolition Plan(s)**

  Provide "demolition" floor plans separate and distinct from "new work" floor plans, except where only minor demolition work is required.

  For modification of or additions to existing equipment, provide the manufacturer's name and other pertinent manufacturer's identification (e.g., serial number, model number, style, and any other manufacturer's identifying markings).

  Clearly show what is to be demolished, at an appropriate scale.

  Indicate the beginning and ending points of circuit removals.

  Provide a sequence of demolition; if necessary, include any known requirement for continuous operation and limited shutdown requirements. These should also be identified in the special scheduling paragraphs of the specifications.

  Indicate the quantity of lighting ballasts that contain PCB's and the quantity of lamps that contain mercury.

- **Lighting Plans**

  Lighting and power shall not be shown on the same floor plan, unless the scale of the plan is ¼" = 1' – 0" or larger.

  Provide a Lighting Fixture Schedule as illustrated on Attachment 23.

- **Power and Communications Plans**

  Power and communication systems may be shown on the same floor plans. However, if there is extensive communication work to be shown, provide separate power and communication plans.

  See paragraph entitled "HVAC Equipment" and "Motor Ratings" in the "Electrical Engineering Design Requirements" section. Specifically identify each piece of equipment (e.g., unit heater No. 1, unit heater No. 2, etc.). See Attachments 24 through 26 for typical illustrations of how to properly display equipment on the contract drawings.

- **Grounding Plan**

  Provide grounding plans and details at an appropriate scale. Provide a grounding detail; see Attachments 29 through 31.

- **Roof Plan**

When roof mounted HVAC equipment cannot be adequately shown on the Power Plan, provide an appropriately scaled roof plan.

- **Lightning Protection Plan**

  Provide lightning protection plan and details at an appropriate scale.

- **Riser Diagrams**

  - **Power One-Line/Riser Diagrams**

    Provide a Power One-Line Diagram for:

    (1) Medium-voltage distribution systems, including substations and switching stations.

    (2) Systems involving generation, either low voltage or medium voltage.

    (3) Building switchgear, switchboards, and main distribution panels (MDP's).

    A one-line diagram is illustrated by Attachment 27. The diagram shall show all components (including metering, protective relaying, etc.), and shall indicate sizes of bus, feeders and conduits. Connections of transformers, PT's, CT's, capacitors, etc., shall be shown on the one-line diagram by means of the proper symbol. Show potential and current transformer ratios. Indicate relay quantity and function (overcurrent, voltage, differential, etc.) using ANSI designation numbers.

    On most projects, it would be appropriate to combine the one-line diagram with a riser diagram. The one-line diagram would begin with the medium voltage system and continue through the transformer up to and including the main breaker and feeder breakers within the MDP. Sub-panels beyond the MDP would be shown in the riser diagram format. A combined one-line/riser diagram is illustrated by Attachment 28.

    Indicate kV ratings for surge arresters, and kV and ampere rating for cutouts. Indicate fuse link type and ampere rating.

    For capacitors indicate kVAR per unit, number of units per bank, voltage (voltage rating of units, not the system voltage), phase (e.g., three-phase or single-phase units), fuse size and type.

  - **Provide a Telecommunications Riser Diagram showing:**

    (1) Service entrance cable and duct, entrance protector assemblies, and connections to existing outside cable plant.

    (2) Cross-connects. Indicate by notation that voice and data cables terminate in separate fields. Indicate method of cross-connecting – patch panel or connector block.

    (3) Telecommunications outlets – include room numbers.

    (4) Cable for building backbone and horizontal distribution system.

(5) Pathway, including conduit and cable tray for backbone and horizontal distribution system.

(6) Telecommunications grounding system.

- **Provide an Intercommunication/Paging Riser Diagram showing:**

  (1) Power source

  (2) Master station with associated equipment

  (3) Speakers, outlets, etc. – include room numbers

  (4) Wiring/conduit between components

- **Provide a Fire Alarm Riser Diagram:**

  See the Fire Protection Design Guide for specific guidance.

- **Other:**

  Provide other riser diagrams in similar way as telephone or intercommunication/paging.

- **Schedules and Elevations**

  Provide panelboard schedules on the drawings in the format shown in Attachments 32 and 33. Schedule shall reflect the actual circuit breaker and bus arrangement. Include the following:

  (1) Panelboard designation

  (2) Voltage

  (3) Phase

  (4) Frequency (if other than 60 Hz)

  (5) Main amperes

  (6) Main breakers or lugs only

  (7) Surface or flush mounting

  (8) Minimum interrupting rating

  (9) Circuit number, wire size, breaker trip, load in amperes, and identification of load associated with each branch or feeder. Please note that identification of load must be specific. For example, the directory marking should not merely indicate “lighting,” but rather “lighting, Room 102.”

  (10) Total connected load

  (11) Any special requirements:

(a) GFI – ground fault interrupter

(b) SWD – rated for switching duty

(12) Total number of poles

Provide elevation drawings for switchboards and switchgear, showing compartments, their intended use, and instruments and controls.

Clearly indicate that switchboards and switchgear must be mounted on 4-inch elevated concrete pads. Coordinate design of pad with structural engineer.

Provide elevation drawings for Motor Control Centers (MCC's) identifying compartments. Provide schedule listing each compartment. Schedule shall include (for each compartment) description of load, load in amperes, load in horsepower, NEMA size and type of starter, breaker size, conductor and conduit size, control devices, and other special requirements.

(1) Also indicate, on plans or in specifications, enclosure type, bus rating, bus material, bus bracing, NEMA class and wiring type, service voltage, control voltage and source, and top or bottom feed.

(2) Clearly indicate on the drawings MCC's must be mounted on 4-inch elevated concrete pads. Coordinate design of pad with structural engineer.

Provide elevation of control panels, indicating front panel devices, such as indicator lights, pushbuttons, gauges, switches, etc.

- **Lighting Fixture Sketches**

Provide lighting fixtures sketches listed in UFGS-16510N, "Interior Lighting" and UFGS-16520N, "Exterior Lighting",wherever possible. Do not modify UFGS-16510N and UFGS-16520N sketches; any required exceptions or modifications must be made in the remarks column of the lighting fixture schedule and not on the sketches themselves. Provide applicable lighting fixture type symbol(s) with each lighting fixture sketch/detail. When using fixture(s) not included with UFGS-16510N and UFGS-16520N, detail the fixture(s) on the drawings providing the following minimum information:

(1) Fixture type (e.g., high bay, fluorescent, industrial, downlight, roadway type, floodlight, etc.)

(2) Physical construction including housing material and fabrication method, description of lens, reflector, refractor, etc.

(3) Electrical data including number of lamps, lamp type, ballast data, operating voltage, etc.

(4) Mounting (surface, suspended, flush, etc.) and mounting height

(5) Special characteristics such as wet label, specific hazardous classification, air handling, etc.

- **Details/Diagrams**

Indicate details as required.

Provide a Grounding Diagram beginning with the medium-voltage system and continuing through the transformer up to and including the MDP, step down transformers and sub-panels. Examples of grounding diagrams are illustrated by Attachments 29 through 31.

- **Pole Sketches**

  Indicate overhead distribution pole sketches on the drawings whenever applicable. In situations where an applicable pole sketch has not been developed, provide detail(s) as required. Designer developed details must contain level of detail equivalent to the pole sketches and include material requirements.

- **Cathodic Protection Plan**

  Provide cathodic protection plans and details at appropriate scales. Indicate on the drawing the location of all rectifiers, anode beds, structures protected by cathodic protection system(s) and all structures which may be affected by stray current corrosion as a result of cathodic protection of the specific structure within the affected area of cathodic protection.

- **Instrumentation and Control Drawings**

  Indicate location of equipment to be controlled.

  Indicate location of control and sensing devices, such as valves, level switches, pressure switches, etc.

  Provide a sequence of operation – may be in specifications, if deemed more appropriate.

  Indicate location of control panel. Provide elevation indicating front panel devices, such as indicator lights, pushbuttons, gauges, switches, etc., if required.

  Indicate location of data transmission devices, when remote annunciation/control is required.

  Provide illustration of PC and programmable operator interface displays, as applicable.

  Provide riser/block diagrams indicating control and sensing devices, control connections between equipment, data transmission devices, and control panels. Do not provide relay logic diagrams, AC schematics, or DC schematics; these diagrams will be developed by the contractor and submitted for approval.

  Provide power wiring and conduit.

  Provide control wiring and conduit.

• Design Submittals

- **35% Design Development Submittal**

- **Basis of Design**

  Submit a complete basis of design

- **Drawings**

  Submit as a minimum the following:

  (1) Title Sheet and Index of Drawings (if project is electrical lead)

  (2) General Sheet (Vicinity Map, Location Plan etc., if project is electrical lead)

  (3) Legends and Abbreviations

  (4) Site Plans

  (5) Demolition Plans

  (6) Lighting Plans (no wiring is required)

  (7) Power and Communications Plans (no wiring is required)

  (8) Lightning Protection Plan (no details required)

  (9) Riser Diagrams

  (10) Cathodic Protection Plan (include the location of the soil resistivity measurements; no details required)

- **Calculations**

  Submit preliminary calculations to substantiate design level shown.

- ## 100% Prefinal Submittal

  - **Basis of Design**

    Submit corrected basis of design and the designer marked up copy.

  - **Drawings**

    Submit all drawings listed under design services. Drawings shall be 100% complete. Also submit the 35% designer marked up copy.

  - **Calculations**

    Submit all calculations to substantiate design level shown.

- ## Final Submittal

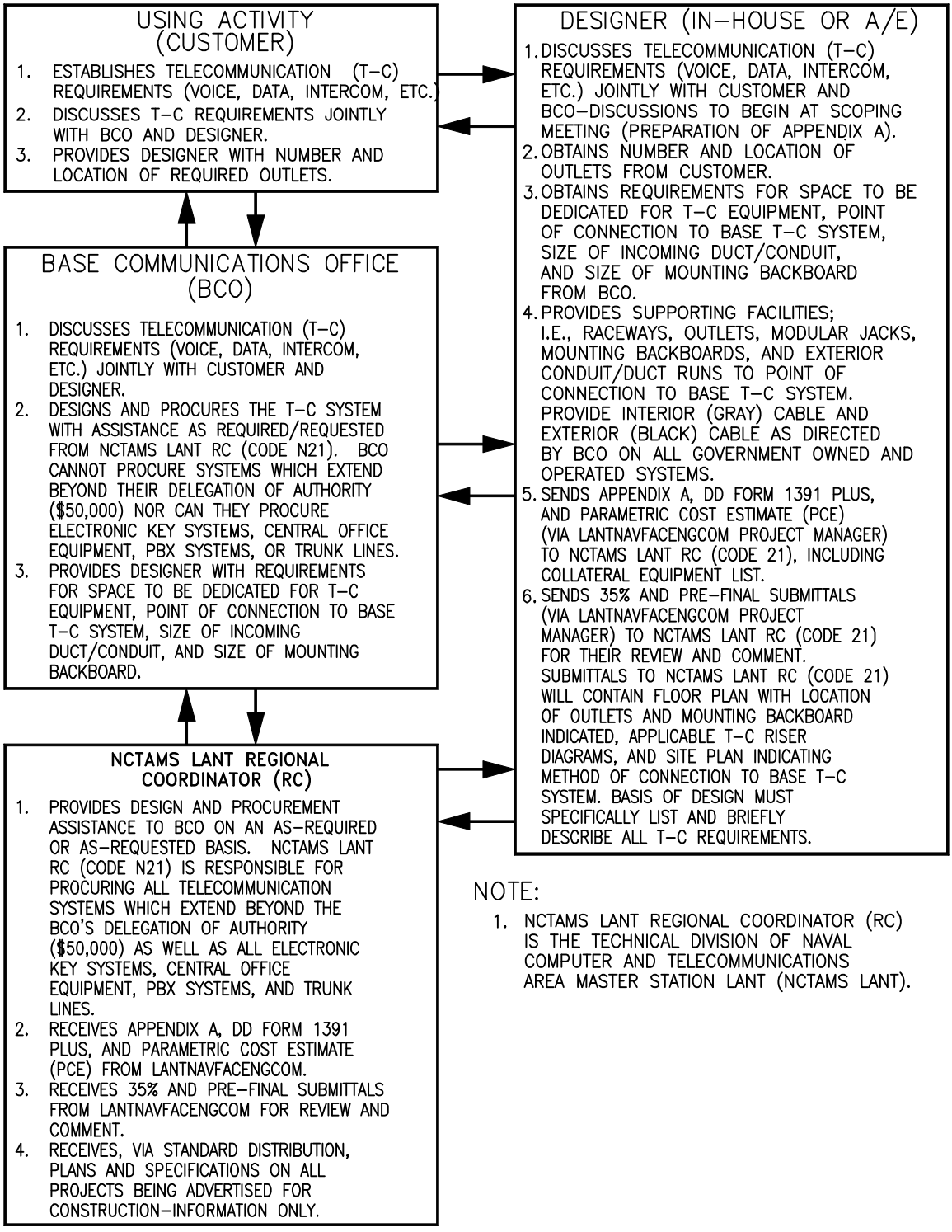
  - **Drawings**

    Submit all corrected drawings listed under design services. Also submit the 100% designer marked up copy.

- **Calculations**

  Submit final calculations to substantiate final design.

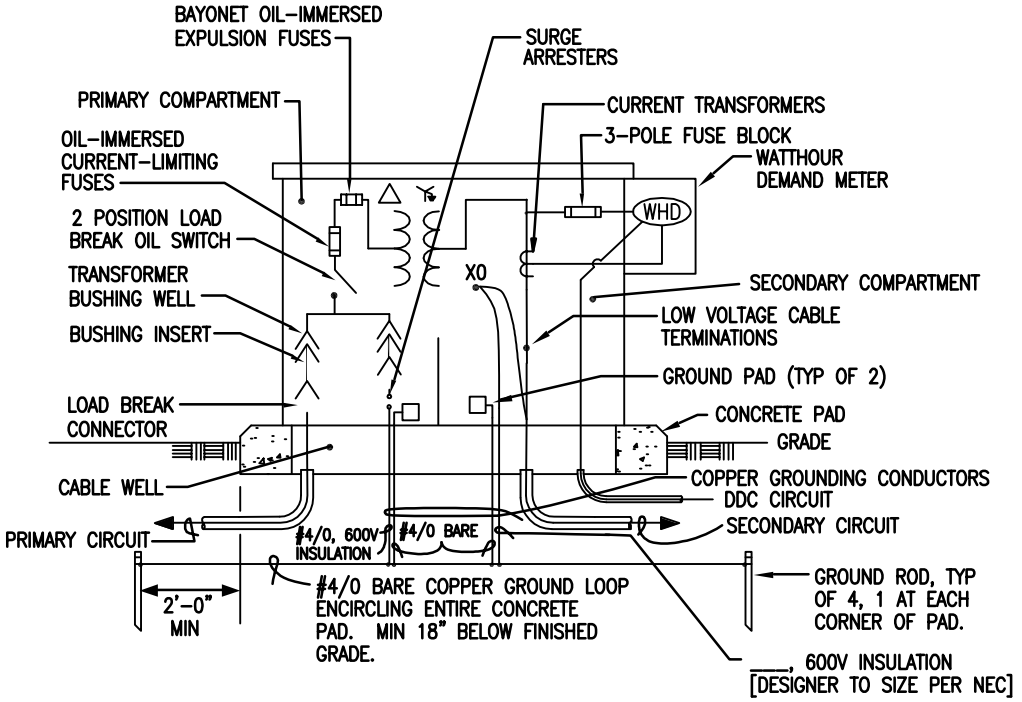
TELECOMMUNICATIONS COORDINATION AND RESPONSIBILITY CHART



NOTE:

1. NCTAMS LANT REGIONAL COORDINATOR (RC) IS THE TECHNICAL DIVISION OF NAVAL COMPUTER AND TELECOMMUNICATIONS AREA MASTER STATION LANT (NCTAMS LANT).

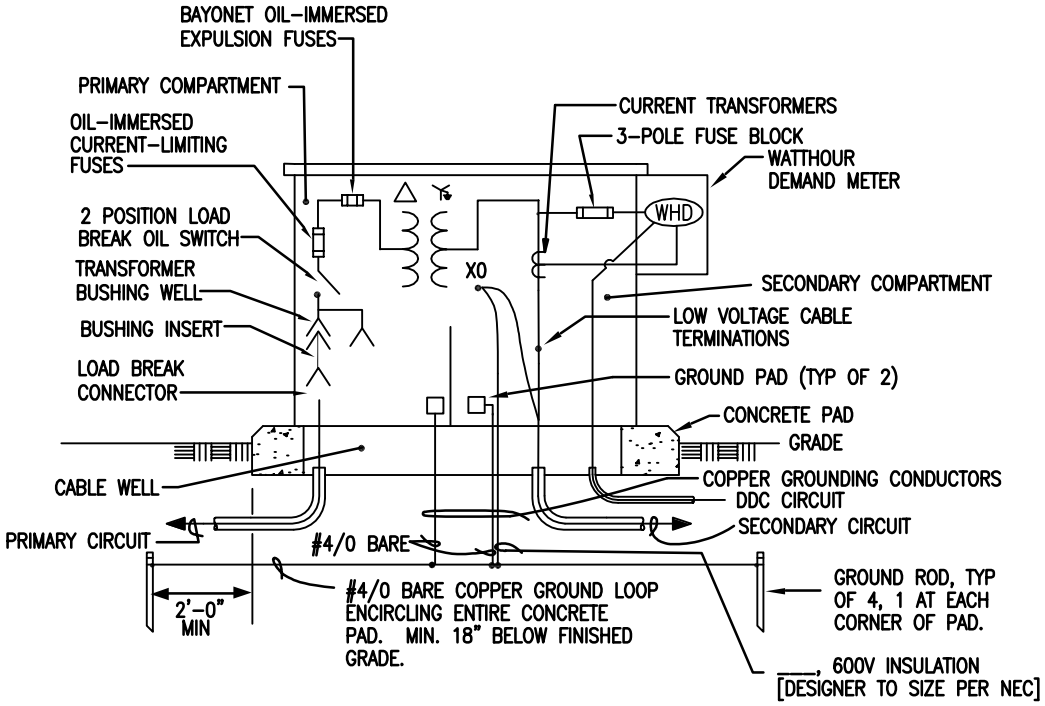
ATTACHMENT 1



PAD-MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

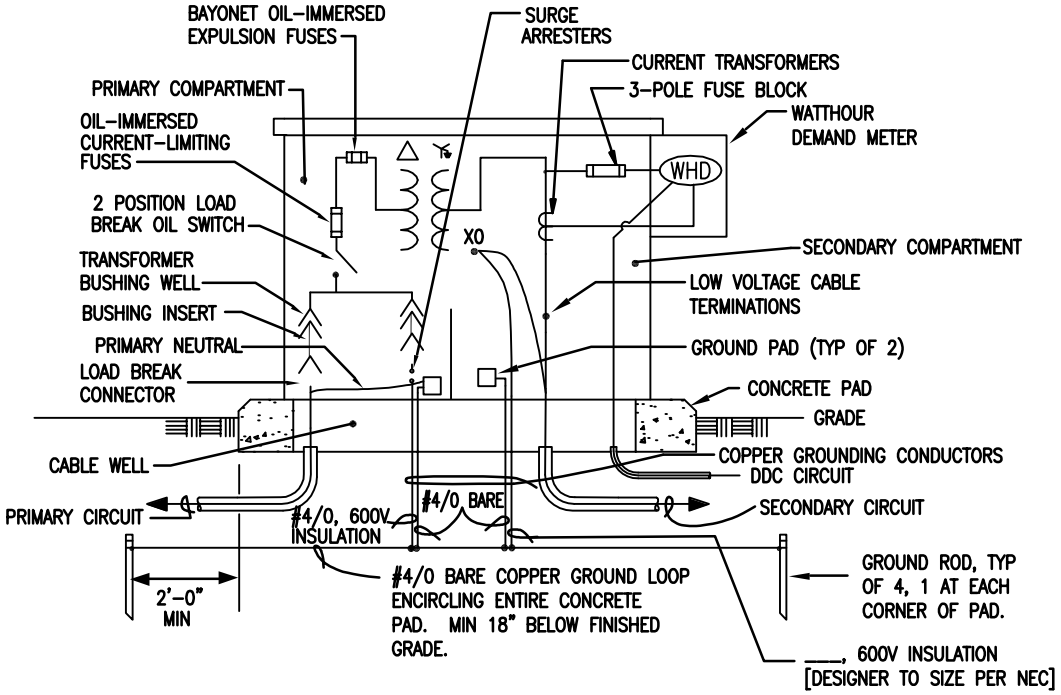
[UNGROUNDED OR SINGLE GROUNDED PRIMARY SYSTEM - WITH SURGE ARRESTERS]



PAD-MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

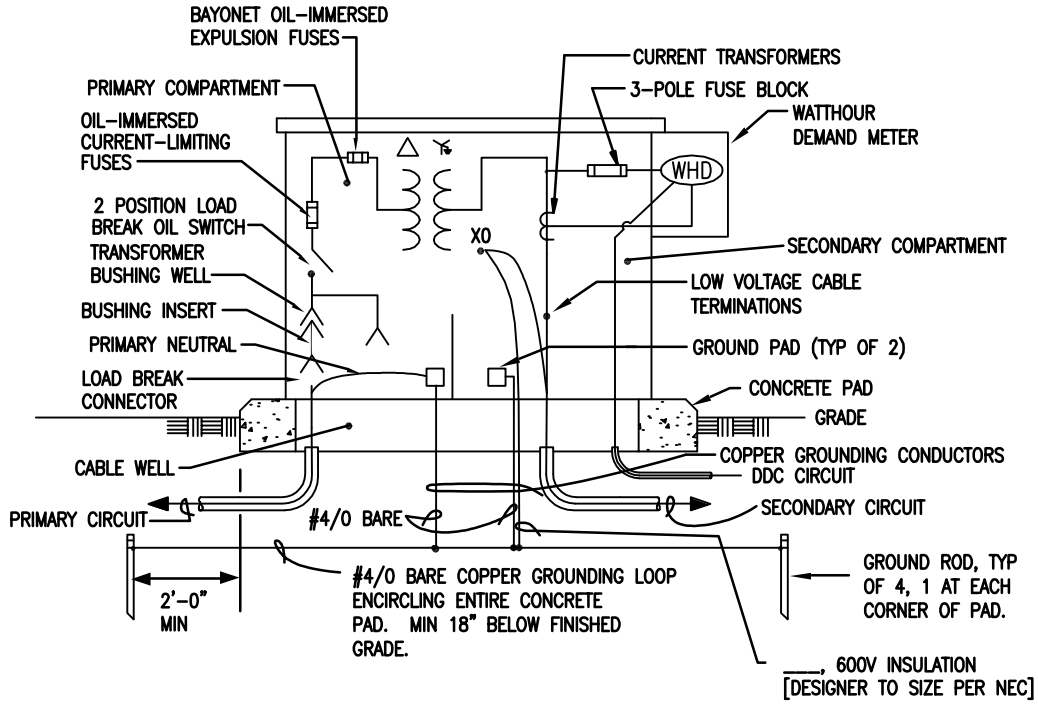
[UNGROUNDED OR SINGLE GROUNDED PRIMARY SYSTEM - WITHOUT SURGE ARRESTERS]



PAD–MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

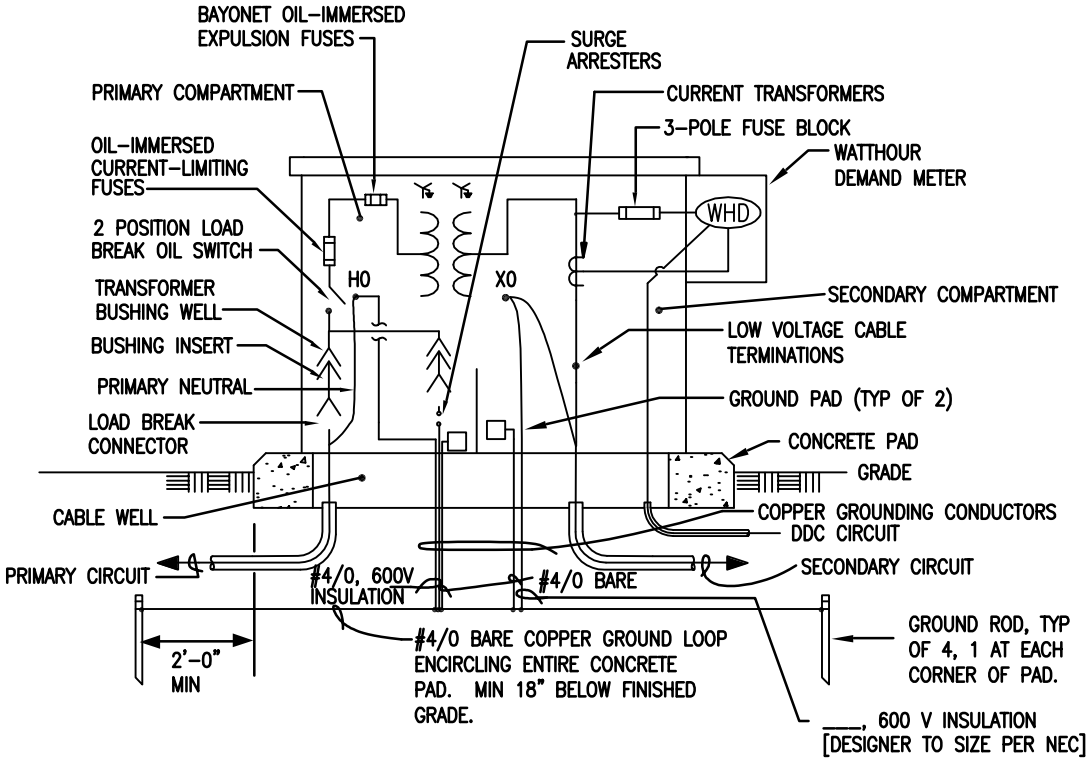
[MULTI–GROUNDED PRIMARY SYSTEM (DELTA–WYE) – WITH SURGE ARRESTERS]



PAD–MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

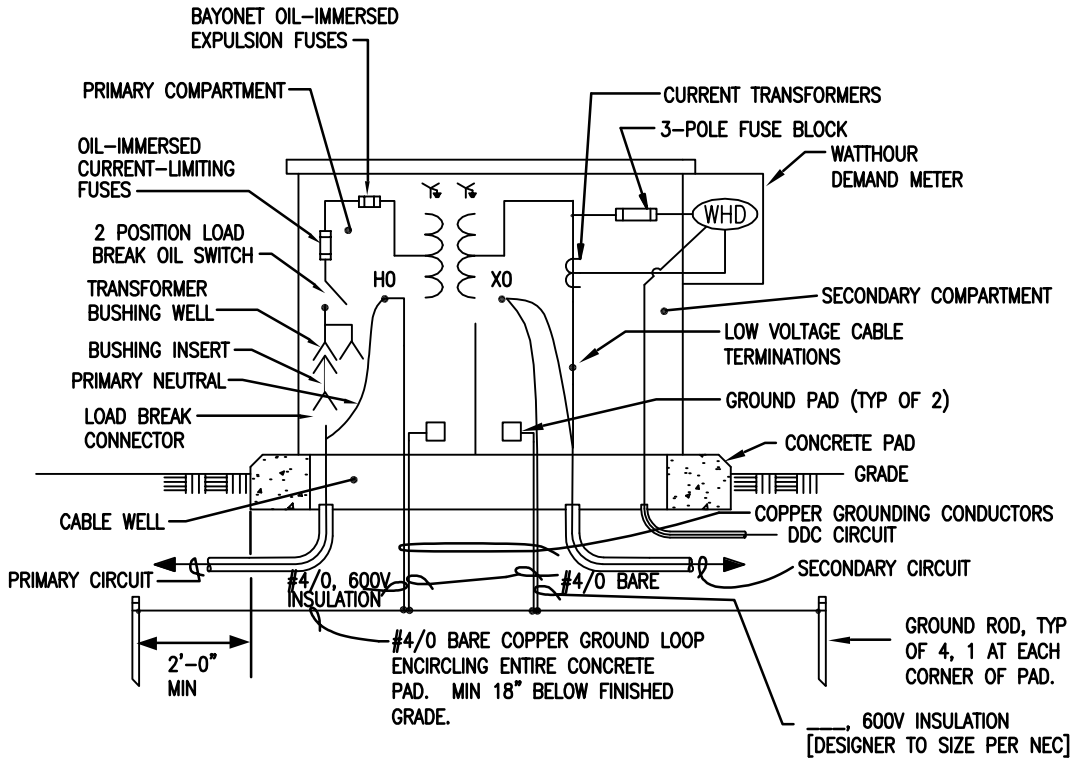
[MULTI–GROUNDED PRIMARY SYSTEM (DELTA–WYE) – WITHOUT SURGE ARRESTERS]



PAD–MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

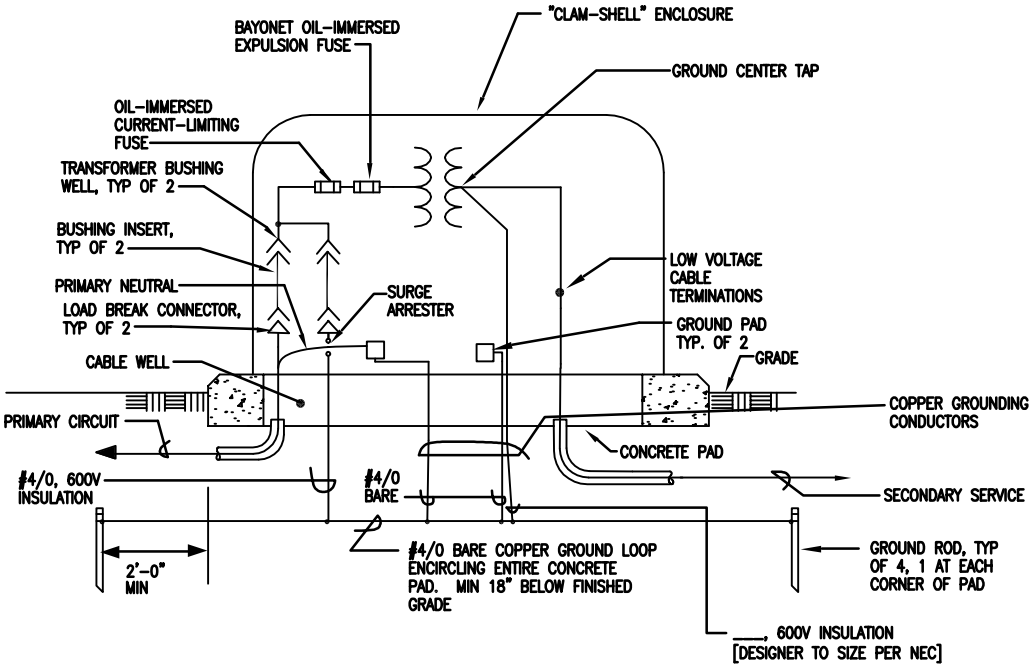
[MULTI–GROUNDED PRIMARY SYSTEM (WYE–WYE) – WITH SURGE ARRESTERS]



PAD–MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

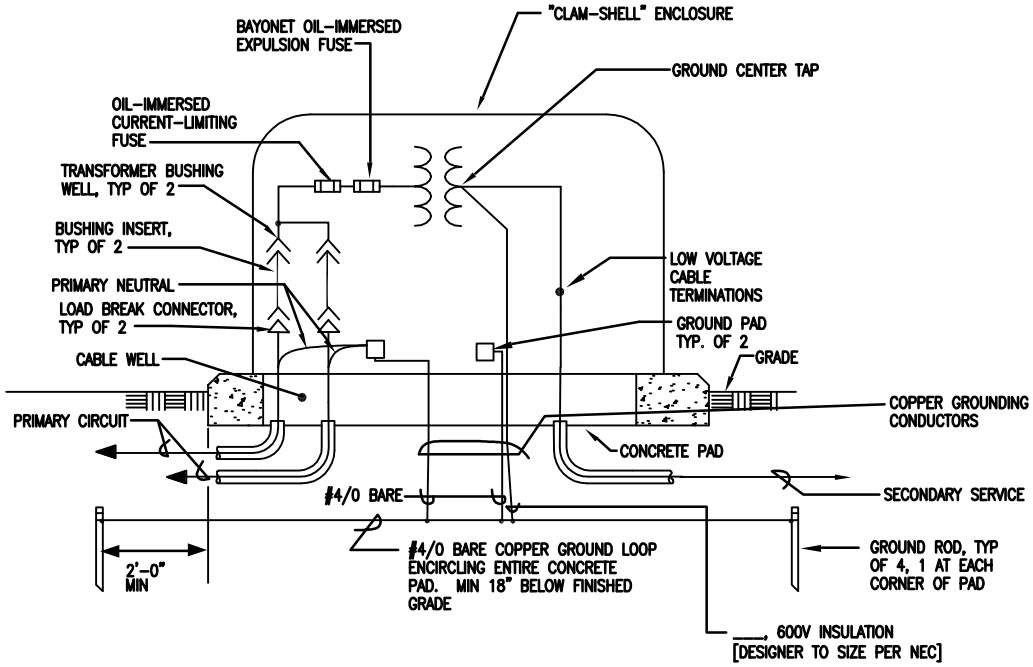
[MULTI–GROUNDED PRIMARY SYSTEM (WYE–WYE) – WITHOUT SURGE ARRESTERS]



SINGLE PHASE PAD-MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

[PHASE-NEUTRAL CONNECTION SHOWN]
[DEAD FRONT LOOP FEED CONFIGURATION (ONE CIRCUIT W/ARRESTER)]



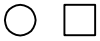
SINGLE PHASE PAD-MOUNTED TRANSFORMER DETAIL

NOT TO SCALE

[PHASE-NEUTRAL CONNECTION SHOWN]
[DEAD FRONT LOOP FEED CONFIGURATION (FEED-THRU CIRCUIT)]

7/02

ELEC. GUIDE LEGEND – (INTERIOR)

SYMBOL	DESCRIPTION
	FLUORESCENT LIGHTING FIXTURE.
	FLUORESCENT EMERGENCY AND/OR NIGHT LIGHTING FIXTURE.
	INCANDESCENT OR HIGH INTENSITY DISCHARGE LIGHTING FIXTURE.
	EXIT LIGHTING FIXTURE. ARROW, WHEN USED, INDICATES DIRECTION.
	LIGHTING FIXTURE TYPE. SEE LIGHTING FIXTURE SCHEDULE ON SHEET E-__
	EMERGENCY BATTERY POWERED LIGHTING UNIT.
	DUPLEX CONVENIENCE RECEPTACLE. 15 A., 125 VAC. MOUNT __ AFF UON
	DOUBLE DUPLEX CONVENIENCE RECEPTACLE. 15 A., 125 VAC. MOUNT __ AFF UON.
	DUPLEX CONVENIENCE RECEPTACLE WITH INTERNAL GROUND FAULT PROTECTION. __ A., 125 VAC. MOUNT __ AFF UON
	SINGLE RECEPTACLE. __ A., ___VAC. MOUNT __ AFF UON
	FLUSH FLOOR DUPLEX RECEPTACLE. 15 A., 125 VAC.
	FLUSH FLOOR SINGLE RECEPTACLE. __ A., 125 VAC.
	CLOCK OUTLET, 15A., 125 VAC MOUNT __ AFF
	SPECIAL PURPOSE RECEPTACLE. ____ A.,__ POLE, __ WIRE, ____VAC. MOUNT __ AFF UON NOTE TO DESIGNER: USE SAME SYMBOL & FORMAT AS ABOVE FOR ADDITIONAL SPECIAL PURPOSE OUTLETS/RECEPTACLES. DIFFERENTIATE BETWEEN TYPE BY USING SUBSCRIPT.
S	SINGLE POLE SWITCH. 20A., 120/277V.
S_A	SINGLE POLE SWITCH. 20A., 120/277V. LOWER CASE SUBSCRIPT, WHEN USED, INDICATES FIXTURES CONTROLLED.
S_2	DOUBLE POLE SWITCH. 20A., 120/277V.
S_3	THREE-WAY SWITCH. 20A., 120/277V.
S_4	FOUR-WAY SWITCH. 20A., 120/277V.
S_D	DIMMER SWITCH. _____ WATTS UON
S_A	KEY OPERATED SWITCH.
S_M	[MOTOR RATED SWITCH][MANUAL MOTOR STARTER SWITCH] WITH OVERLOADS.
S_P	SWITCH WITH PILOT LIGHT.

ATTACHMENT 6

SYMBOL	DESCRIPTION
Ⓔ	EQUIPMENT CONNECTION AS NOTED.
Ⓙ	JUNCTION BOX.
Ⓜ 1/2	MOTOR CONNECTION, HP INDICATED.
⊠	MAGNETIC MOTOR CONTROLLER.
3P 60/40	DISCONNECT SWITCH. ___V IN NEMA __ ENCLOSURE UON 3P = NO. OF POLES, 60 = SWITCH RATING, 40 = FUSE RATING (NF INDICATES NON-FUSIBLE).
	ELECTRICAL PANELBOARD (208Y/120 VOLT).
	ELECTRICAL PANELBOARD (480Y/277 VOLT).
W/W	WIREWAY.
OR	BRANCH CIRCUIT OR FEEDER WIRING IN CONDUIT. NO TICK MARKS INDICATE 2 #12 CONDUCTORS & 1 #12 GND. IN 1/2" CONDUIT UON. TICK MARKS, WHEN SHOWN, INDICATE NUMBER OF #12 CONDUCTORS IF OTHER THAN THREE; (✓) INDICATES GROUND. CONDUIT LARGER THAN 1/2" & WIRE LARGER THAN #12 SHALL BE AS INDICATED.
A-1,3,5	HOMERUNS TO PANEL. PANEL & CIRCUIT DESIGNATIONS AS INDICATED.
	INDICATES A CONDUIT RUN CONCEALED IN CEILING, WALL, FLOOR, OR ABOVE SUSPENDED CEILING UON. NOTE TO DESIGNER: INDICATE BY NOTE ON DRAWINGS WHERE EXPOSED CONDUITS ARE TO BE USED.
	CONDUIT TURNED UP.
	CONDUIT TURNED DOWN.
	CONDUIT SEAL.
	TELEPHONE TERMINAL BACKBOARD.
△	TELEPHONE OUTLET, MOUNT __ AFF
△p	PAY TELEPHONE OUTLET. MOUNT __ AFF

SYMBOL	DESCRIPTION
TV	TELEVISION SYSTEM OUTLET, MOUNT __ AFF
S	SPEAKER.
△IC	INTERCOM OUTLET, MOUNT __ AFF
Ⓣ	LINE VOLTAGE THERMOSTAT, MOUNT __ AFF
CS	CONTROL STATION.
•	PUSH BUTTON.
T	DRY TYPE TRANSFORMER.
T/S	TIME SWITCH
Ⓟ	PHOTO-ELECTRIC CONTROL.
FACP	FIRE ALARM CONTROL PANEL (FACP).
F	FIRE ALARM MANUAL STATION, MOUNT __ AFF
▷F c	FIRE ALARM STROBE/CHIME, MOUNT __ AFF
▷F m	FIRE ALARM MINI-HORNS, MOUNT __ AFF
▷F	FIRE ALARM STROBE/HORN, MOUNT __ AFF
F	FIRE ALARM __-INCH BELL, MOUNT __ AFF
FCT	FIRE ALARM SYSTEM CODED TRANSMITTER.
F	MASTER FIRE ALARM BOX WITH LOCATION LIGHT.
V	FIRE ALARM SYSTEM VISUAL STROBE, MOUNT __ AFF
Ⓢ$_F$	FIRE ALARM SYSTEM SMOKE DETECTOR. MOUNT ON CEILING UON SUBSCRIPT "F", WHEN USED, INDICATES DETECTOR UNDER RAISED FLOOR.
Ⓓ	DUCT SMOKE DETECTOR.
⟨S⟩	120-VAC SINGLE-STATION SMOKE DETECTOR, HARD WIRED INTO THE ELECTRICAL SOURCE AS INDICATED.
⟨T⟩	SPRINKLER SYSTEM TAMPER SWITCH.
Ⓗ	FIRE ALARM SYSTEM HEAT DETECTOR.
⟨F⟩	SPRINKLER SYSTEM FLOW SWITCH.
⟨P⟩	SPRINKLER SYSTEM PRESSURE SWITCH.
⟨K⟩	KITCHEN HOOD FIRE EXTINGUISHING SYSTEM SWITCH.
T	REMOTE FIRE ALARM SYSTEM TROUBLE BELL (OR BUZZER).
M	MAGNETIC DOOR HOLDER.

ATTACHMENT 8

IDS SYMBOLS:

SYMBOL	DESCRIPTION
AS	ACCESS SWITCH
BS	BALANCED MAGNETIC SWITCH
CR	CARD READER WITHOUT KEY PAD
CK	CARD READER WITH KEY PAD
CP	CENTRAL PROCESSING UNIT
CU	CONTROL UNIT
DA	DURESS ALARM
DR	DOOR STRIKE
K	KEY PAD
MU	MONITORING UNIT
PI	PASSIVE INFARED SENSOR
R	REQUEST TO EXIT SWITCH

ABBREVIATIONS

AFF	ABOVE FINISHED FLOOR
AFG	ABOVE FINISHED GRADE
ARF	ABOVE RAISED FLOOR
C	CONDUIT
CB	CIRCUIT BREAKER
CKT	CIRCUIT
EC	EMPTY CONDUIT
EQUIP	EQUIPMENT
EWC	ELECTRIC WATER COOLER
EWH	ELECTRIC WATER HEATER
EXIST	EXISTING
EXP	INDICATES EXPLOSION PROOF EQUIPMENT
GFCI	GOVERNMENT FURNISHED CONTRACTOR INSTALLED
GFGI	GOVERNMENT FURNISHED GOVERNMENT INSTALLED
GFI	GROUND FAULT INTERRUPTER
GND	GROUND
HID	HIGH INTENSITY DISCHARGE
MLO	MAIN LUGS ONLY
MT	MOUNT
MTG HT	MOUNTING HEIGHT
MCB	MAIN CIRCUIT BREAKER
NIC	NOT IN CONTRACT
NTS	NOT TO SCALE

ABBREVIATIONS

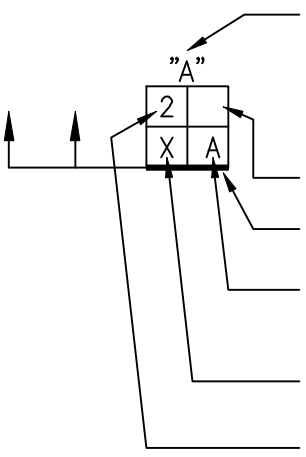
PNL	PANEL
PNLBD	PANELBOARD
RECEPT	RECEPTACLE
REQ'D	REQUIRED
XFMR	TRANSFORMER
UON	UNLESS OTHERWISE NOTED
WP	INDICATES WEATHERPROOF EQUIPMENT

NOTES:

1. WHERE BLANK SPACES OCCUR, INSERT APPROPRIATE DATA.
2. WHERE DATA IS ENCLOSED IN BRACKETS [ ], A CHOICE MUST BE MADE. DELETE INAPPLICABLE DATA.
3. THIS LEGEND PROVIDES BASIC SYMBOLS. MODIFY LEGEND AS REQUIRED TO PROPERLY DIFFERENTIATE BETWEEN "NEW", "EXISTING TO REMAIN" & "EXISTING REMOVE".

ELEC. GUIDE LEGEND–(EXTERIOR UNDERGROUND)

SYMBOL	DESCRIPTION
———	UNDERGROUND DUCTBANK, CONCRETE ENCASED UON. DESCRIPTION AS INDICATED.
— — —	EXISTING UNDERGROUND DUCTBANK, CONCRETE ENCASED UON. DESCRIPTION AS INDICATED.



SYMBOL REFERS TO SPECIFIC DUCTBANK SECTION DETAIL. (SEE NOTE 1)

DUCTBANK SECTION LOOKING IN DIRECTION OF ARROWS. (SEE NOTE 2)

SPARE DUCT (TYPICAL)

HEAVY LINE INDICATES BOTTOM OF DUCT

EXIST. CABLE DESIGNATION (TYPICAL)
DESCRIPTION PER CABLE SCHEDULE. (SEE NOTE 3)

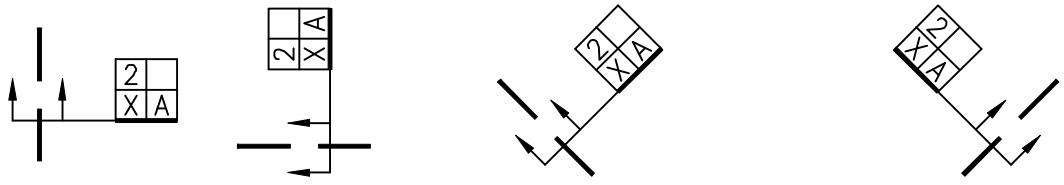
OCCUPIED DUCT, UNIDENTIFIED CABLE.

NEW CABLE DESIGNATION (TYPICAL)
DESCRIPTION PER CABLE SCHEDULE. (SEE NOTE 3)

DUCTBANK NOTES TO DESIGNER:

1– USE THIS SYMBOL ONLY WHEN SPECIFIC DUCTBANK SECTIONS ARE REQUIRED TO INDICATE SPECIAL CONDITIONS, SUCH AS STEEL REINFORCING, WHICH WOULD INVALIDATE THE DUCT SPACING AND CONCRETE ENCASEMENT INFORMATION GIVEN IN THE GUIDE SPECIFICATIONS. INCLUDE THE REQUIRED DUCTBANK SECTIONS ON THE DRAWINGS AND MODIFY THE SPECIFICATIONS.

2– DISPLAY DUCTBANK SECTIONS IN ANY OF THE FOLLOWING ACCEPTABLE WAYS:



3– PROVIDE A CABLE SCHEDULE CONTAINING CABLE DESIGNATION SYMBOLS, CABLE DESCRIPTIONS, CONDUIT SIZES, ROUTING AND OTHER INFORMATION THAT MAY BE NECESSARY. THIS INFORMATION SHOULD NOT BE REPEATED ELSEWHERE ON THE DRAWINGS. IDENTIFY CABLE SHOWN ON SITE PLANS, FLOOR PLANS, RISER DIAGRAMS, ETC. BY ITS CABLE DESIGNATION SYMBOL ONLY.

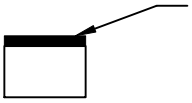
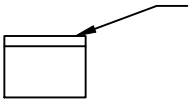
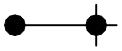
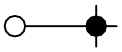
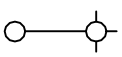
SYMBOL	DESCRIPTION
——— UP ———	UNDERGROUND CONDUIT, CONCRETE ENCASED UON. DESIGNER TO DESCRIBE CABLE AND CONDUIT. EXAMPLE: 3–1/C 500 KCMIL (15KV) & 1 500 KCMIL NEUTRAL (600V) IN 5" C.
— — US — —	EXISTING UNDERGROUND CONDUIT, CONCRETE ENCASED UON DESIGNER TO DESCRIBE CABLE AND CONDUIT. EXAMPLE: 4 #2 (600V) IN 3" C.
⋇ ⋇USL⋇ ⋇	REMOVE EXISTING CIRCUIT. ABANDON CONDUIT IN PLACE UON. DESIGNER TO DESCRIBE CABLE. EXAMPLE: 3–1/C, 120 VOLT STREET LIGHT CABLE.

TYPICAL DESIGNATIONS TO BE USED IN CONJUNCTION WITH CONDUIT SYMBOLS

- UP– UNDERGROUND PRIMARY
- US– UNDERGROUND SECONDARY
- UT– UNDERGROUND TELEPHONE
- UFA– UNDERGROUND FIRE ALARM
- USL– UNDERGROUND STREET LIGHTING
- UTV– UNDERGROUND TELEVISION CABLE

——— G ———	GROUNDING CONDUCTOR. DESIGNER TO DESCRIBE.
⊡	MANHOLE OR HANDHOLE, AS NOTED.
⊡	EXISTING MANHOLE OR HANDHOLE AS NOTED.
⊡⊡	EXISTING COMBINATION POWER/COMMUNICATION MANHOLE.

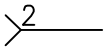
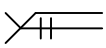
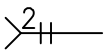
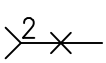
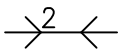
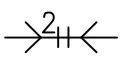
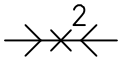
NOTE TO DESIGNER: REQUEST MANHOLE & HANDHOLE DESIGNATION NUMBERS FROM THE ACTIVITY. DO NOT USE ARBITRARILY ASSIGNED NUMBERS UNLESS STATION PROVIDED NUMBERS ARE NOT AVAILABLE. IF NUMBERS ARE NOT AVAILABLE, PRE–FINAL SUBMITTAL MUST STATE THIS FACT AND INDICATE INDIVIDUAL (NAME AND TELEPHONE NUMBER) AT THE ACTIVITY WHO WAS CONTACTED.

SYMBOL	DESCRIPTION
	INDICATES FRONT. PAD MOUNTED TRANSFORMER. DESIGNER TO PROVIDE DESCRIPTION. EXAMPLE: 75KVA, 3 PHASE, 12KV–208Y/120 VOLTS.
	INDICATES FRONT. EXISTING PAD MOUNTED TRANSFORMER. DESIGNER TO PROVIDE DESCRIPTION. EXAMPLE: 25KVA, 1 PHASE, 2.4KV–120/240 VOLTS. NOTE TO DESIGNER: FOR UNIT SUBSTATIONS AND OTHER MAJOR PIECES OF ELECTRICAL EQUIPMENT SHOW APPROXIMATE EQUIPMENT OUTLINE ON PLANS, PROPERLY IDENTIFY, INDICATE FRONT OF EQUIPMENT.
	PAD MOUNTED SWITCH. DESIGNER TO PROVIDE DESCRIPTION. EXAMPLE: 15KV, 3 WAY, 600 AMP NON–FUSED, OIL.
	EXISTING PAD MOUNTED SWITCH. DESIGNER TO PROVIDE DESCRIPTION. EXAMPLE: 5KV, 4 WAY, 200 AMP FUSED, AIR.
	AREA/STREET LIGHTING POLE WITH LUMINAIRE. DESIGNER TO PROVIDE DESCRIPTION. EXAMPLE: 400 WATT, 120 V. WITH 6' MOUNTING ARM.
	EXISTING AREA/STREET LIGHTING POLE WITH LUMINAIRE. DESIGNER TO PROVIDE DESCRIPTION. EXAMPLE: 400 WATT, 120 V. WITH 6' MOUNTING ARM.
	EXISTING AREA/STREET LIGHTING POLE WITH EXISTING LUMINAIRE. DESIGNER TO PROVIDE DESCRIPTION.
	LIGHTING FIXTURE TYPE. SEE LIGHTING FIXTURE SCHEDULE ON SHEET E–__

ABBREVIATIONS

C	CONDUIT
HH	HANDHOLE
MH	MANHOLE
UG	UNDERGROUND
XFMR	TRANSFORMER
UON	UNLESS OTHERWISE NOTED

ELEC. GUIDE LEGEND–(EXTERIOR–OVERHEAD)

SYMBOL	DESCRIPTION
●	POWER POLE (HEIGHT AND CLASS AS INDICATED).
●^{R}	REMOVE EXISTING AND PROVIDE NEW POWER POLE (HEIGHT AND CLASS AS INDICATED).
○	EXISTING POWER POLE (HEIGHT AND CLASS AS INDICATED).
⊗	REMOVE EXISTING POWER POLE (HEIGHT AND CLASS AS INDICATED).
	NOTE TO DESIGNER: REQUEST POLE NUMBERS FROM THE ACTIVITY. DO NOT USE ARBITRARILY ASSIGNED NUMBERS UNLESS STATION PROVIDED NUMBERS ARE NOT AVAILABLE. IF NUMBERS ARE NOT AVAILABLE, PRE–FINAL SUBMITTAL MUST STATE THIS FACT AND INDICATE INDIVIDUAL (NAME AND TELEPHONE NUMBER) AT THE ACTIVITY WHO WAS CONTACTED.
	DOWN GUY AND ANCHOR – QUANTITY AS INDICATED IF OTHER THAN ONE.
	EXISTING DOWN GUY AND ANCHOR – PROVIDE ADDITIONAL DOWN GUY TO EXISTING ANCHOR.
	EXISTING DOWN GUY AND ANCHOR – QUANTITY AS INDICATED IF OTHER THAN ONE.
	REMOVE EXISTING DOWN GUY AND ANCHOR – QUANTITY AS INDICATED IF OTHER THAN ONE.
	SPAN GUY – QUANTITY AS INDICATED IF OTHER THAN ONE.
	EXISTING SPAN GUY – QUANTITY AS INDICATED IF OTHER THAN ONE.
	REMOVE EXISTING SPAN GUY – QUANTITY AS INDICATED IF OTHER THAN ONE.
	POLE MOUNTED TRANSFORMER – SINGLE PHASE WITH KVA AS INDICATED.
	EXISTING POLE MOUNTED TRANSFORMER – SINGLE PHASE WITH KVA AS INDICATED.
	REMOVE POLE MOUNTED SINGLE PHASE TRANSFORMER – KVA AS INDICATED.

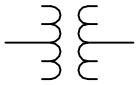
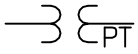
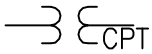
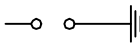
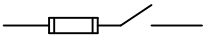
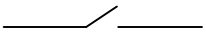
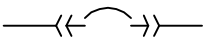
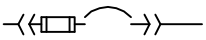
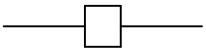
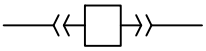
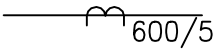
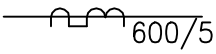
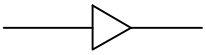
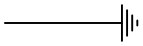
SYMBOL	DESCRIPTION
——13.2——	13.2 KV, 3 PHASE, 3 WIRE CIRCUIT # 1/0 B. ALUM. UNLESS OTHERWISE NOTED. NOTE TO DESIGNER: MODIFY UNDERLINED DATA TO MATCH CIRCUIT VOLTAGE, SYSTEM AND CONDUCTOR CHARACTERISTICS. PROVIDE TICKMARKS, IF DESIRED, TO FURTHER INDICATE NUMBER OF CONDUCTORS. TYPICAL COMMENT FOR ALL CIRCUIT SYMBOLS.
– –13.2– –	EXISTING 13.2 KV, 3PHASE, 3WIRE CIRCUIT – #4 W.P. CU.
✳ ✳13.2✳ ✳	REMOVE 13.2 KV, 3 PHASE, 3WIRE CIRCUIT – 477 B. ALUM.
—— N ——	ONE WIRE COMMON NEUTRAL – #4 B. CU.
– – N – –	EXISTING ONE WIRE COMMON NEUTRAL – #4/0 B. ALUM.
✳ ✳ N ✳ ✳	REMOVE ONE WIRE COMMON NEUTRAL – #4 W.P. CU.
– – G – –	EXISTING ONE WIRE GROUND (STATIC) – 3/8" STEEL.
✳ ✳ G ✳ ✳	REMOVE ONE WIRE GROUND (STATIC) – 5/16" STEEL.
—— SL ——	2 WIRE SERIES TYPE STREET LIGHTING CIRCUIT – #6 W.P. CU.
– – SL – –	EXISTING 1 WIRE SERIES TYPE STREET LIGHTING CIRCUIT – #4 B. CU.
✳ ✳ SL ✳ ✳	REMOVE 2 WIRE SERIES TYPE STREET LIGHTING CIRCUIT – #6 B. CU.
—— FA ——	2 WIRE FIRE ALARM CIRCUIT – #8 W.P. CU.
– – FA – –	EXISTING 2 WIRE FIRE ALARM CIRCUIT – #8 W.P. CU.
✳ ✳ FA ✳ ✳	REMOVE 2 WIRE FIRE ALARM CIRCUIT – #8 W.P. CU.
—— S ——	OPEN 3 WIRE 120/240 VOLT SECONDARY CIRCUIT.
– – S – –	EXISTING OPEN 3 WIRE 480Y/277 VOLT SECONDARY CIRCUIT.
✳ ✳ S ✳ ✳	REMOVE EXISTING OPEN 3 WIRE 240/480 VOLT SECONDARY CIRCUIT.

SYMBOL	DESCRIPTION
—— SD ——	120 VOLT SECONDARY (DUPLEX) CIRCUIT – #4 ALUM INSULATED PHASE CONDUCTOR WITH #4 B. ALUM NEUTRAL CONDUCTOR.
– – SD – –	EXISTING 240 VOLT SECONDARY (DUPLEX) CIRCUIT – #4 COPPER.
✶ ✶ SD ✶ ✶	REMOVE 120 VOLT SECONDARY (DUPLEX) CIRCUIT – #4 COPPER.
—— ST ——	120/240 VOLT SECONDARY (TRIPLEX) CIRCUIT – #2 COPPER INSULATED PHASE CONDUCTORS WITH #2 B. CU. NEUTRAL CONDUCTOR.
– – ST – –	EXISTING 120/240 VOLT SECONDARY (TRIPLEX) CIRCUIT – #2 ALUM.
✶ ✶ ST ✶ ✶	REMOVE 120/240 VOLT SECONDARY (TRIPLEX) CIRCUIT – #4/0 ALUM.
—— SQ ——	208Y/120 VOLT SECONDARY (QUADRUPLEX) CIRCUIT – #1/0 ALUMINUM INSULATED PHASE CONDUCTORS WITH #1/0 B. ALUM NEUTRAL CONDUCTOR.
– – SQ – –	EXISTING 208Y/120 VOLT SECONDARY (QUADRUPLEX) CIRCUIT – #1/0 ALUM.
✶ ✶ SQ ✶ ✶	REMOVE 208Y/120 VOLT SECONDARY (QUADRUPLEX) CIRCUIT – #1/0 B. ALUM.
—— TD ——	120/240 VOLT TRIPLEX SERVICE DROP – #2 COPPER INSULATED PHASE CONDUCTORS WITH #2 B. COPPER NEUTRAL CONDUCTOR.
– – TD – –	EXISTING 120/240 VOLT TRIPLEX SERVICE DROP – #1/0 COPPER.
✶ ✶ TD ✶ ✶	REMOVE 120/208 VOLT TRIPLEX SERVICE DROP – #1/0 ALUM.
—— QD ——	208Y/120 VOLT QUADRUPLEX SERVICE DROP – #1/0 ALUM.INSULATED PHASE CONDUCTORS WITH #1/0 B. ALUM. NEUTRAL CONDUCTOR.
– – QD – –	EXISTING 208Y/120 VOLT QUADRAPLEX SERVICE DROP – #4/0 ALUM.
✶ ✶ QD ✶ ✶	REMOVE 208Y/120 VOLT QUADRUPLEX SERVICE DROP – #2 COPPER.

SYMBOL	DESCRIPTION
— — D — —	EXISTING 120/240 VOLT OPEN WIRE SERVICE DROP – 3 #4 W.P. CU. .
✳ ✳ D ✳ ✳	REMOVE 120/240 VOLT OPEN WIRE SERVICE DROP – 3 #1/0 W.P. CU. .
—— T ——	100 PAIR TELEPHONE CABLE.
— — T — —	EXISTING 26 PAIR TELEPHONE CABLE.
✳ ✳ T ✳ ✳	REMOVE 100 PAIR TELEPHONE CABLE.
—— TV ——	CABLE OR CLOSED CIRCUIT TELEVISION CABLE.
— — TV — —	EXISTING CABLE OR CLOSED CIRCUIT TELEVISION CABLE.
✳ ✳ TV ✳ ✳	REMOVE CABLE OR CLOSED CIRCUIT TELEVISION CABLE.
—— A ——	SECURITY ALARM OR ANNUNCIATOR CIRCUIT – CHARACTERISTICS AS INDICATED.
— — A — —	EXISTING SECURITY ALARM OR ANNUNCIATOR CIRCUIT – CHARACTERISTICS AS INDICATED.
✳ ✳ A ✳ ✳	REMOVE SECURITY ALARM OR ANNUNCIATOR CIRCUIT – CHARACTERISTICS AS INDICATED.
—— C ——	12 CONDUCTOR, #10 AWG COPPER, 600 VOLT CONTROL CABLE.
— — C — —	EXISTING 18 CONDUCTOR, #12 AWG COPPER, 300 VOLT CONTROL CABLE.
✳ ✳ C ✳ ✳	REMOVE 6 CONDUCTOR, #14 AWG COPPER, 600 VOLT CONTROL CABLE.
—●— (A)	AREA/STREET LIGHTING FIXTURE – TYPE (A) PER LIGHTING FIXTURE SCHEDULE ON SHEET E– .
—○—	EXISTING 120 VOLT, 250 WATT, AREA/STREET LIGHTING FIXTURE.
—⊗—	REMOVE EXISTING 120 VOLT, 400 WATT, AREA/STREET LIGHTING FIXTURE.

ATTACHMENT 18

ELEC. GUIDE LEGEND (ONE-LINE DIAGRAMS)

SYMBOLS	DESCRIPTION
	POWER TRANSFORMER.
	POTENTIAL TRANSFORMER.
	CONTROL POWER TRANSFORMER.
	SURGE ARRESTER.
	FUSED SWITCH.
	DISCONNECT SWITCH.
	MOLDED CASE CIRCUIT BREAKER.
	LOW VOLTAGE DRAW-OUT POWER CIRCUIT BREAKER.
	FUSED LOW VOLTAGE DRAW-OUT POWER CIRCUIT BREAKER.
	MEDIUM VOLTAGE POWER CIRCUIT BREAKER.
	MEDIUM VOLTAGE POWER DRAW-OUT CIRCUIT BREAKER.
	DELTA CONNECTION.
	GROUNDED WYE CONNECTION.
	CURRENT TRANSFORMER – SINGLE RATIO AS SHOWN.
	CURRENT TRANSFORMER – MULTI RATIO (FULL RATIO SHOWN).
	MEDIUM VOLTAGE CABLE TERMINATION.
	EXISTING MEDIUM VOLTAGE CABLE TERMINATION.
	CAPACITOR.
	GROUNDING ELECTRODE CONNECTION.
	CABLE OR BUS, TYPE AND CHARACTERISTICS AS INDICATED.
	EXISTING CABLE OR BUS, TYPE AND CHARACTERISTICS AS INDICATED.

SYMBOL	DESCRIPTION
—x—x—x—	REMOVE CABLE OR BUS, TYPE AND CHARACTERISTICS AS INDICATED.
(A)	AMMETER.
(V)	VOLTMETER.
(W)	WATTMETER.
(WH)	WATTHOUR METER.
(WHD)	WATTHOUR METER WITH DEMAND REGISTER.
(VAR)	VARMETER.
(F)	FREQUENCY METER.
(PF)	POWER FACTOR METER.
(S)	SYNCHROSCOPE.
[AS]	AMMETER SWITCH.
[VS]	VOLTMETER SWITCH.
◇K	KIRK KEY INTERLOCK.
[S]	SHUNT TRIP.
(GFP)	GROUND FAULT PROTECTION.
(GEN)	GENERATOR.
(L)	INDICATING LAMP.
—|||—	BATTERY.
(51)$_3$	RELAY AND ANSI CONTROL FUNCTION SYMBOL. NUMBER OUTSIDE CIRCLE INDICATES QUANTITY IF GREATER THAN ONE.

TYPICALLY USED ANSI CONTROL FUNCTION SYMBOLS

01	CONTROL SWITCH.
2	TIME DELAY RELAY.
15	SPEED OR FREQUENCY MATCHING RELAY.
25	SYNCHRONIZING RELAY.
27	UNDER VOLTAGE RELAY.
32	REVERSE POWER RELAY.
43	SELECTOR SWITCH.
46	NEGATIVE SEQUENCE CURRENT RELAY.
50	INSTANTANEOUS OVERCURRENT RELAY.
51	TIME OVERCURRENT RELAY.
52	AC CIRCUIT BREAKER.
59	OVERVOLTAGE RELAY.
63	SUDDEN PRESSURE RELAY.
67	DIRECTIONAL OVERCURRENT RELAY.
74	ALARM RELAY.
79	AC RECLOSING RELAY.
81	FREQUENCY RELAY.
86	LOCK–OUT RELAY.
87	DIFFERENTIAL RELAY.

ABBREVIATIONS

X	AUXILIARY.
LTC	LOAD TAP CHANGER.
AUTO	AUTOMATIC.
AF	AMP FRAME.
AT	AMP TRIP.
CPT	CONTROL POWER TRANSFORMER.
N	NEUTRAL.

4/98

LIGHTING FIXTURE SCHEDULE					
FIXTURE SYMBOL	SKETCH NO. & TYPE	NUMBER AND TYPE OF LAMPS	VOLTAGE	MOUNTING	NOTES
A	NL-1, TYPE A	2-F32/T8	120	SURFACE	
B	NL-3, TYPE C	2-F32/T8	120	RECESSED	
C	NL-57, TYPE B	1-13W DOUBLE TWIN TUBE FLUOR.	120	RECESSED	
D	NL-4, TYPE A	2-F17/T8	120	WALL 6" AFF	
E	DETAIL "D" SEE SHEET E-6	2-F32/T8	120	SUSPENDED W/1/2" C 12' AFF	
F	NL-9, TYPE E	4-F32/T8	120	RECESSED	32 CELL NATURAL FINISH
G	NL-25, TYPE A	1-70W HPS	120	WALL 10' AFF	
H	NL-51	2-12W HALOGEN	120	WALL 7' AFF	
I	NL-61	LED	120	WALL 7' AFF	

ATTACHMENT 23

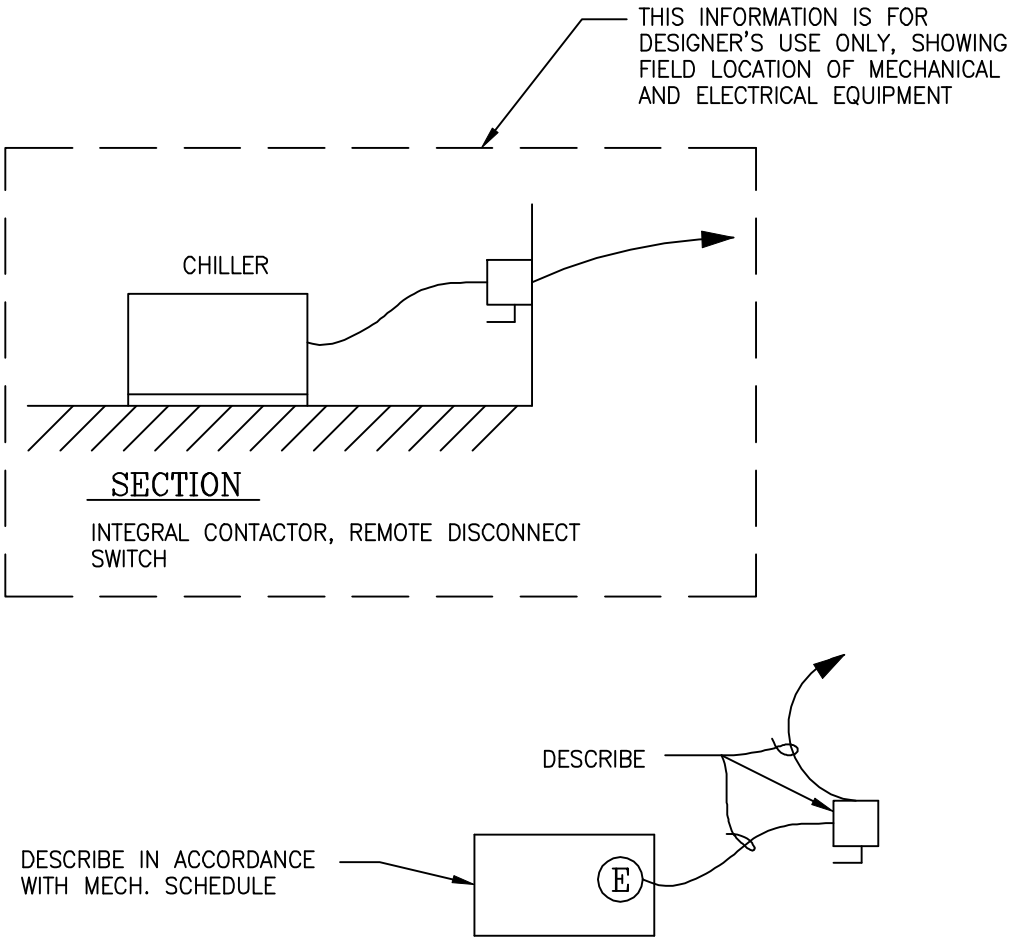
LEGEND (ATTACHMENTS 24–26)

DISCONNECT SWITCH, SIZE & TYPE AS INDICATED

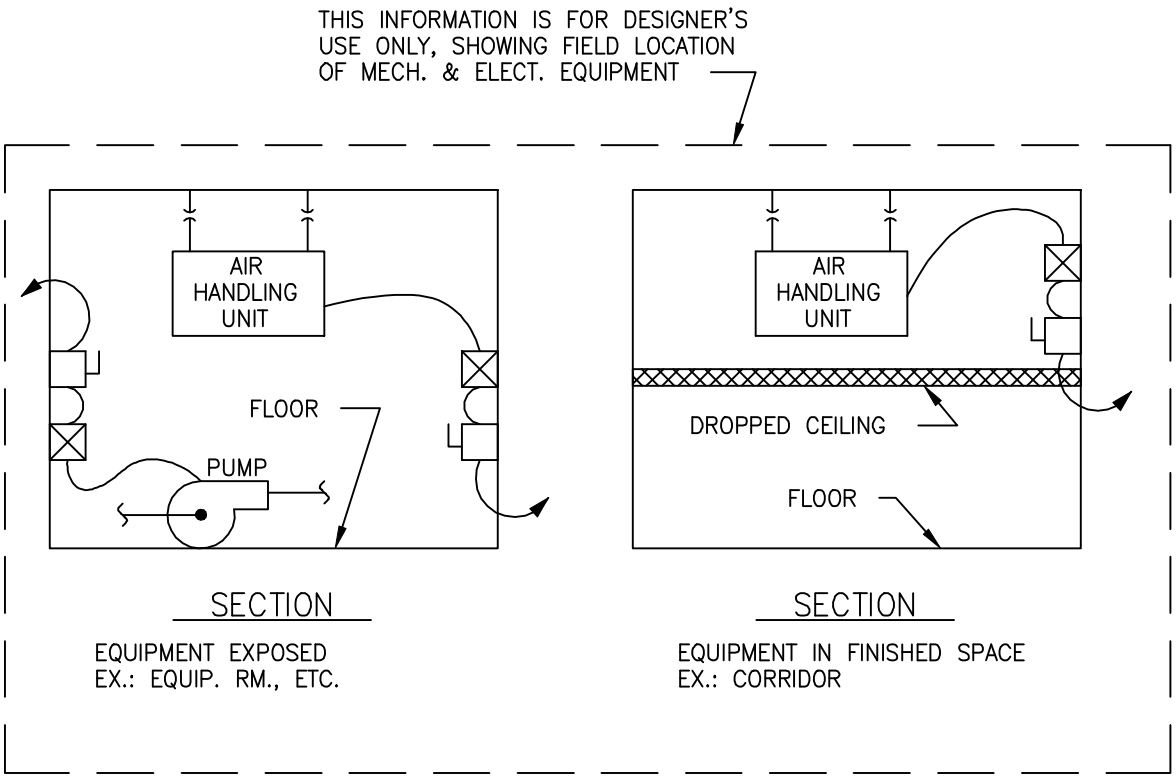
MAGNETIC MOTOR CONTROLLER

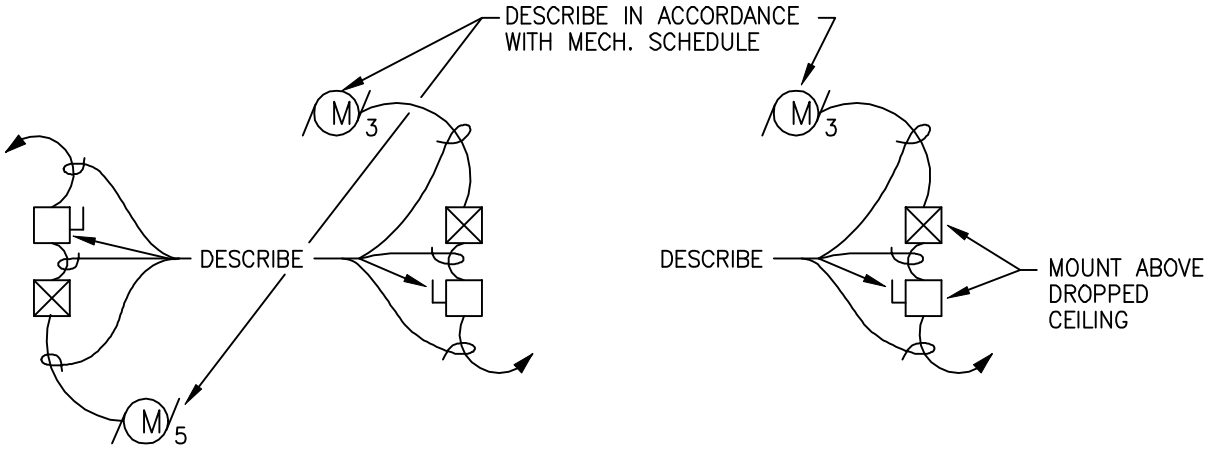
M/5 MOTOR CONNECTION, HP INDICATED

E ELECTRICAL EQUIPMENT CONNECTION



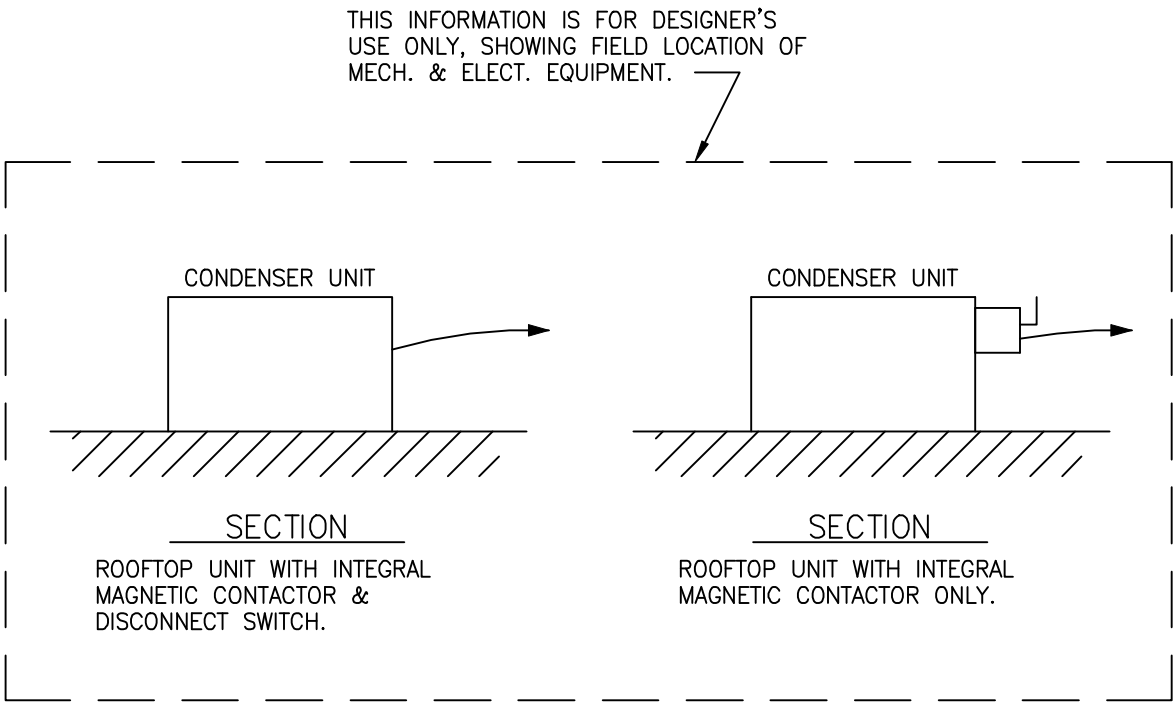
EQUIPMENT CONNECTION ILLUSTRATIONS

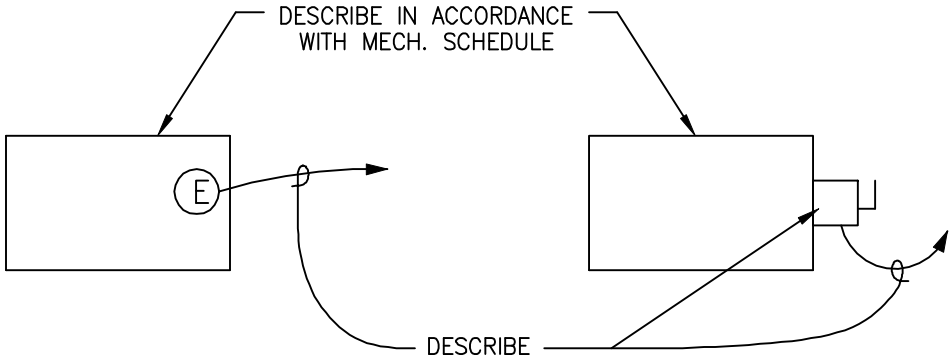




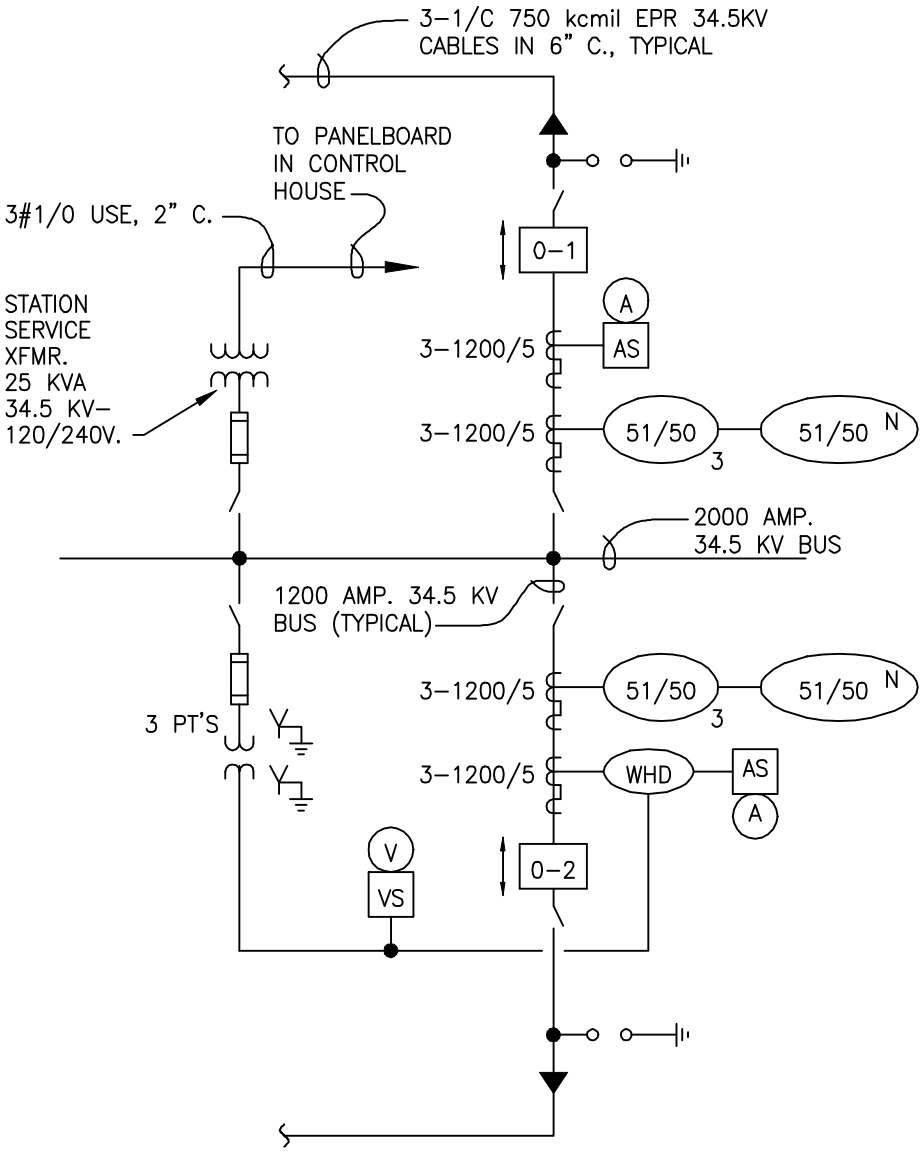
EQUIPMENT CONNECTION ILLUSTRATIONS

ATTACHMENT 25



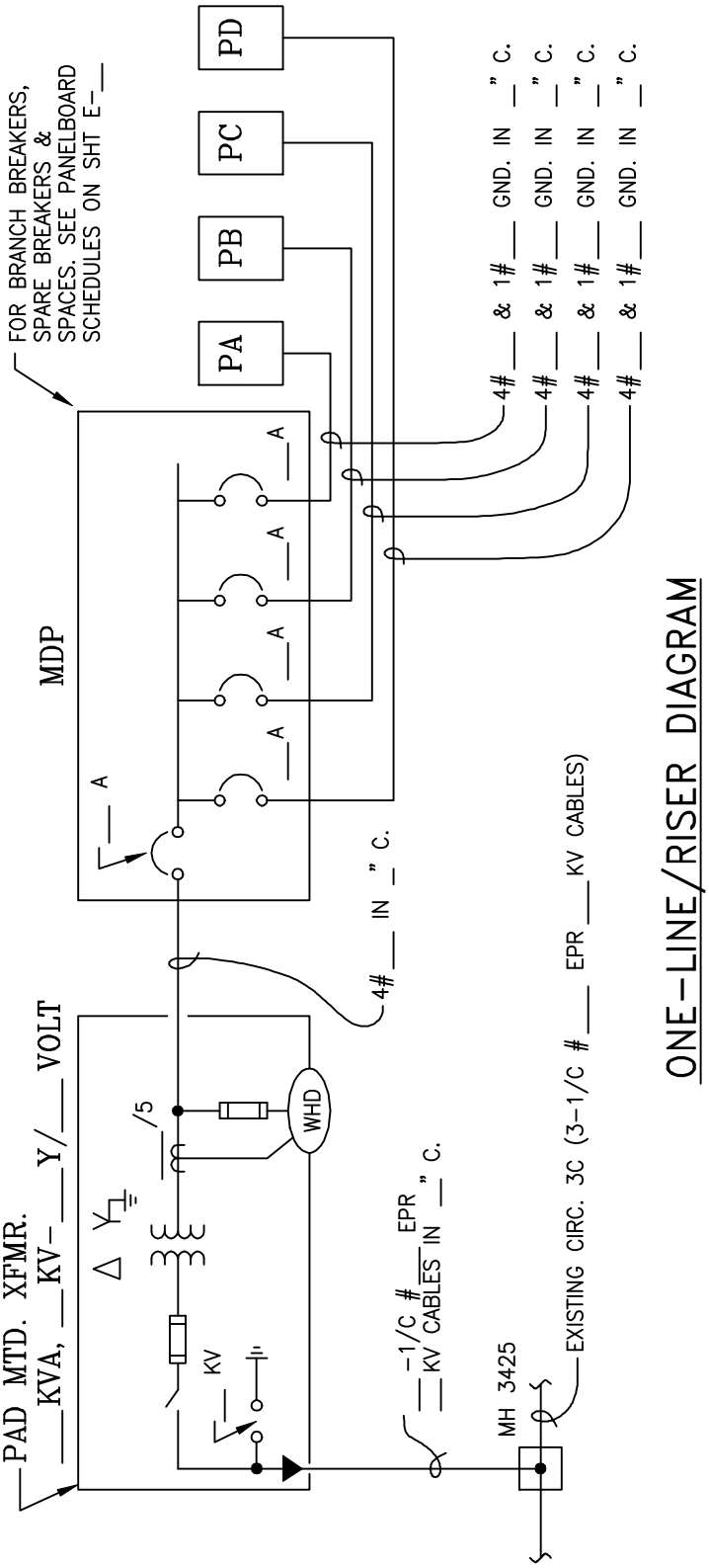


EQUIPMENT CONNECTION ILLUSTRATIONS



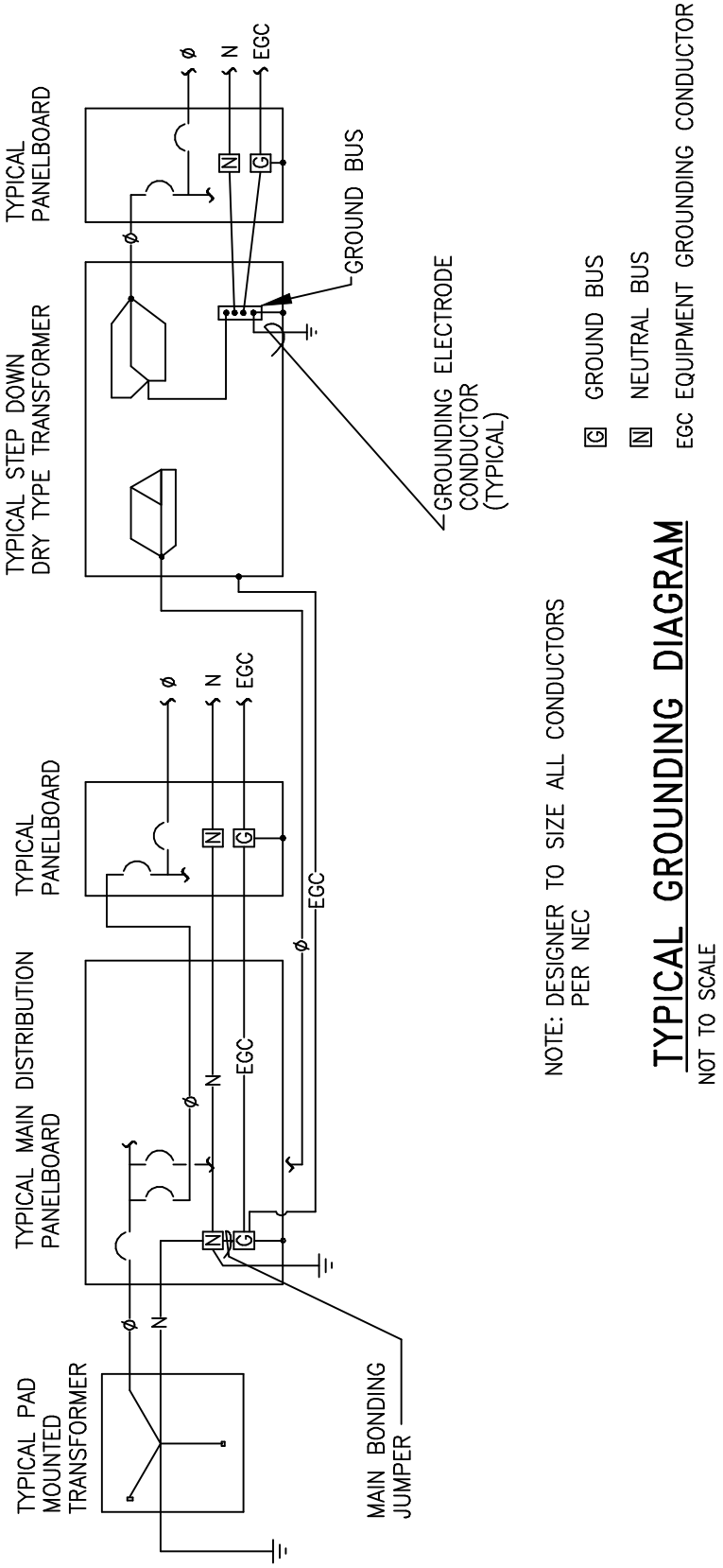
ONE-LINE DIAGRAM

ATTACHMENT 27



ONE-LINE/RISER DIAGRAM

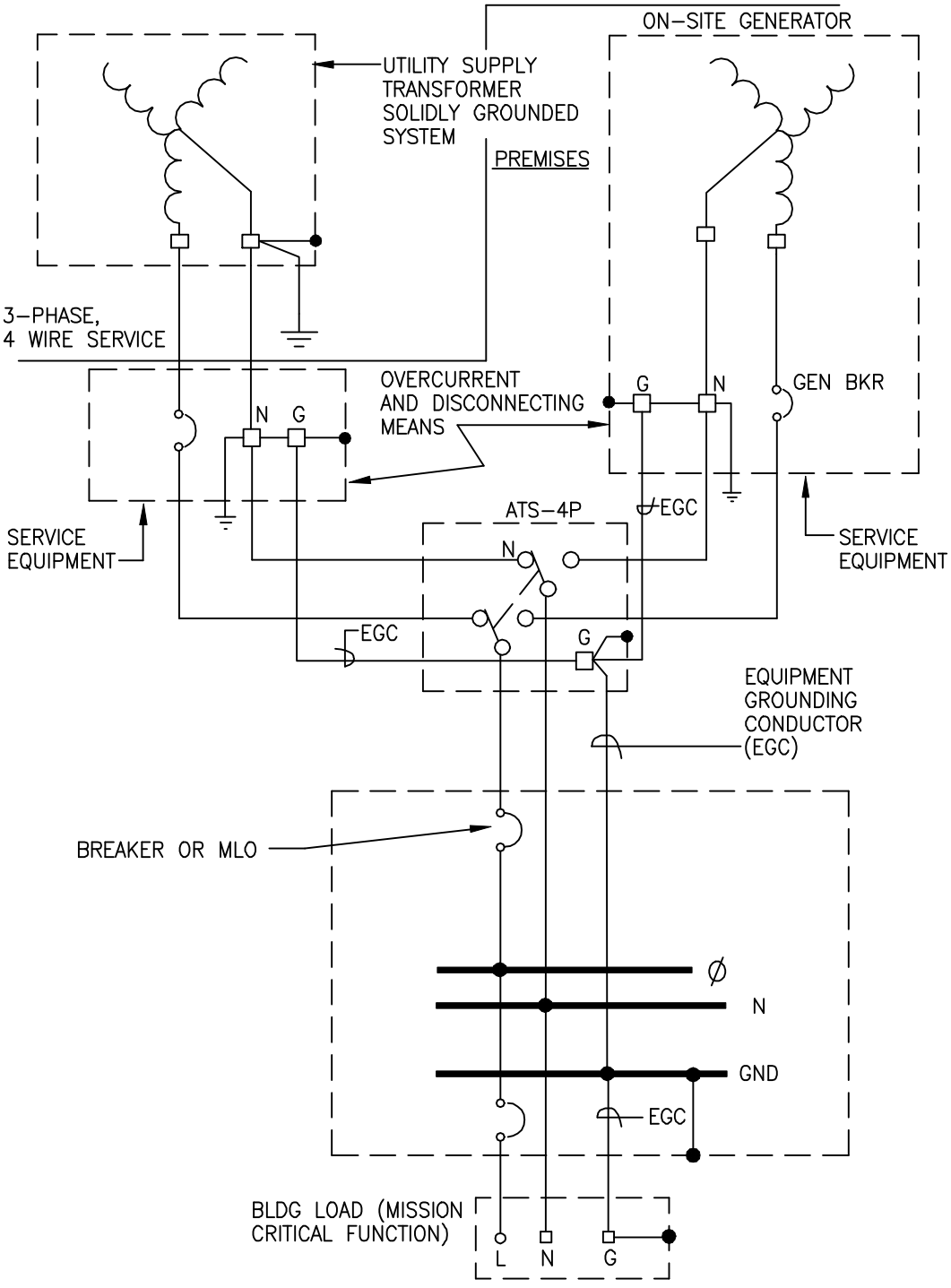
ATTACHMENT 28



TYPICAL GROUNDING DIAGRAM

NOT TO SCALE

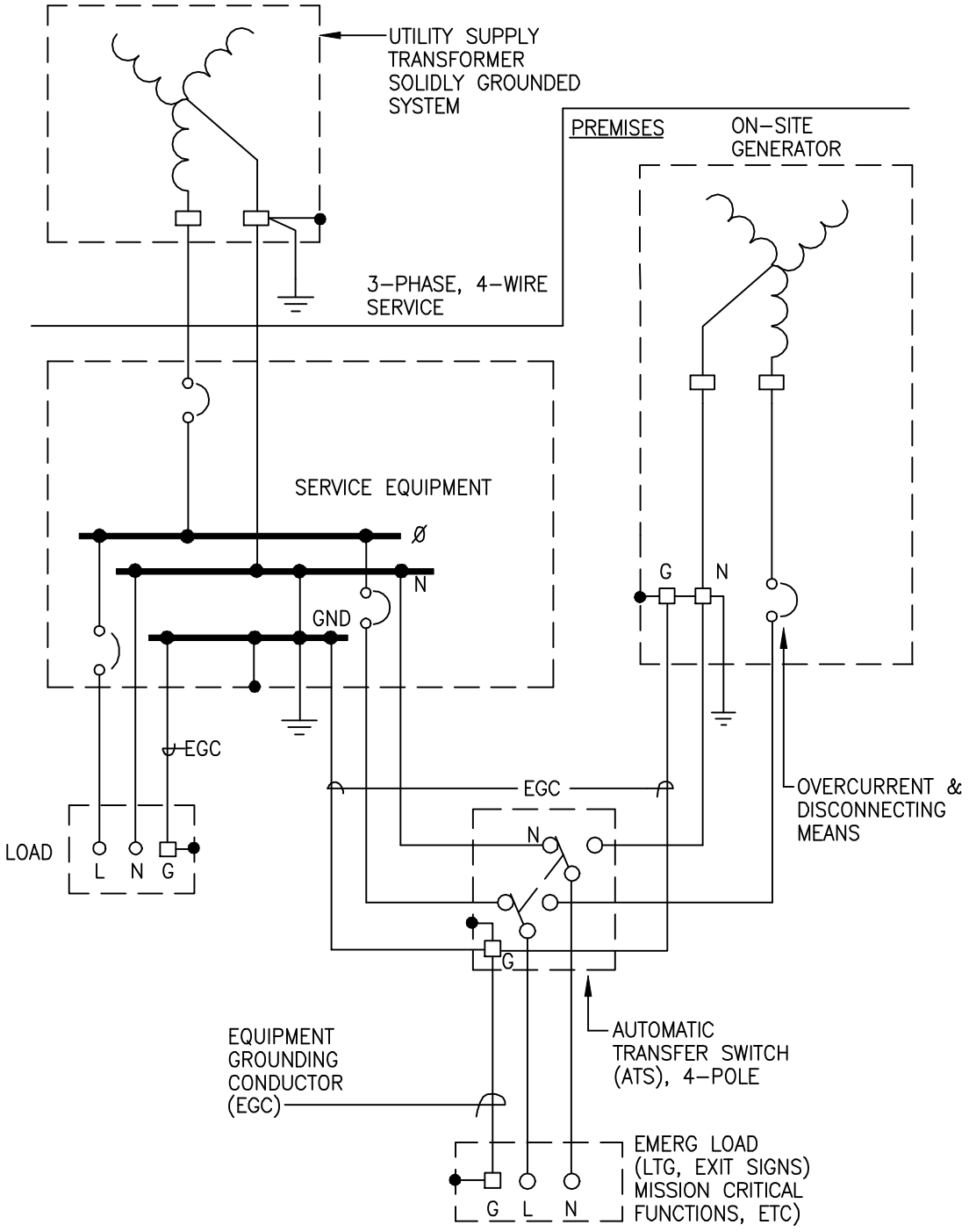
ATTACHMENT 29



GROUNDING DIAGRAM

ALL BUILDING LOADS PROVIDED WITH BACK–UP
EMERGENCY GENERATION

ATTACHMENT 30



GROUNDING DIAGRAM

SELECTED BUILDING LOADS PROVIDED WITH BACK-UP
EMERGENCY GENERATION

ATTACHMENT 31

PANELBOARD MDP SCHEDULE ⟨1⟩

600 A. MAINS W/400A M.C.B., 208Y/120 V., 3 PHASE, 4 WIRE, 10 KAIC MINIMUM, FLUSH MOUNT

LOAD SERVED	LOAD (AMPS) A	B	C	BKR. TRIP	WIRE SIZE	CKT. NO.	PHASE A B C	CKT. NO.	WIRE SIZE	BKR. TRIP	LOAD (AMPS) A	B	C	LOAD SERVED
UH-1 & EF-1 RM. 101	1.5			20	12	1		2	12	20	5.1			UNIT HEATERS RM 105
EF-2 RM. 102		1.6		20	12	3		4	12	20		3.5		UNIT HEATERS RM. 107
EF-5 RM. 103			.58	20	12	5		6	12	20			2	FACP ⟨2⟩
SPARE				20		7		8		20				SPARE
SPARE				20		9		10		20				SPARE
SPACE						11		12						SPACE
SPACE						13		14						SPACE
BAY DOORS RM. 105		11		20	12	15		16						SPACE
			11					18						SPACE
PANEL A	173			100	3	19		20						SPACE
		164												
			168											
ACU-1 RM. 104	6			20	12	25		26	8	50	137			PANEL B
		6										135		
			6										136	
EF-3 RM 107	6			20	12	31		32	8	50	108			PANEL C
		6										113		
			6										137	
EF-4 RM. 106	4.1			20	12	37		38	12	20	4.1			H&V-1 ISSUE RM.
		4.1										4.1		
			4.1										4.1	
TOTAL	191	193	196								254	256	279	TOTAL
TOTAL CONNECTED AMPS A: 445 B: 451 C: 475														

⟨1⟩ PROVIDE SERVICE RATED PANEL. PROVIDE RED LAMINATED PLASTIC LABEL WITH WHITE CENTER CORE WITH THE FOLLOWING INSCRIPTION "EMERGENCY BREAKER WITHIN"

⟨2⟩ PROVIDE LOCK-ON BREAKER PAINTED RED

PANELBOARD C SCHEDULE

225 A., MAIN LUGS ONLY, 208Y/120V., 3 PHASE, 4 WIRE, 10 KAIC MINIMUM, FLUSH MOUNT

LOAD SERVED	LOAD (AMPS) A	B	C	BKR. TRIP	WIRE SIZE	CKT. NO.	PHASE A B C	CKT. NO.	WIRE SIZE	BKR. TRIP	LOAD (AMPS) A	B	C	LOAD SERVED
LIGHTING RM. 100	10.4			20	12	1		2	12	20	10.4			LIGHTING RM. 107
LIGHTING RM. 101		16.0		20	12	3		4	12	20		16.0		LIGHTING RM. 108
LIGHTING RM. 102			16.0	20	12	5		6	12	20			16.0	LIGHTING RM. 109
LIGHTING RM. 103	5.8			20	12	7		8	12	20	10.4			LIGHTING RM. 110
LIGHTING RM. 104		10.4		20	12	9		10	12	20		16.0		LIGHTING RM. 111
LIGHTING RM. 105			10.4	20	12	11		12	12	20			16.0	LIGHTING RM. 112
LIGHTING RM. 106	15.0			20	12	13		14	12	20	10.4			LIGHTING RM. 113
SPARE				20		15		16		20				SPARE
SPARE				20		17		18		20				SPARE
SPACE						19		20						SPACE
SPACE						21		22						SPACE
RECEPTACLES RM. 100			10.4	20	12	23		24	12	20			10.5	RECEPTACLES RM. 107
RECEPTACLES RM. 101	10.4			20	12	25		26	12	20	12.0			RECEPTACLES RM. 108
RECEPTACLES RM. 102		15.0		20	12	27		28	12	20		9.0		RECEPTACLES RM. 109
RECEPTACLES RM. 103			14.2	20	12	29		30	12	20			9.0	RECEPTACLES RM. 110
RECEPTACLES RM. 104	10.4			20	12	31		32	12	20	10.5			RECEPTACLES RM. 111
RECEPTACLES RM. 105		16.0		20	12	33		34	12	20		15.0		RECEPTACLES RM. 112
RECEPTACLES RM. 106			16.0	20	12	35		36	12	20			7.5	RECEPTACLES RM. 113
SPACE						37		38	12	20	2			TELEPHONE BACKBOARD
SPACE						39		40						SPACE
SPACE						41		42						SPACE
TOTAL	52.0	57.4	67.0								55.7	56.0	69.5	TOTAL
TOTAL CONNECTED AMPS A: 107.7 B: 113.4 C: 136.5														

PANELBOARD I SCHEDULE

100 A. MAIN LUGS ONLY, 120/240 V., 1 PHASE, 3 WIRE, 10 KAIC MINIMUM, SURFACE MOUNT

LOAD SERVED	LOAD (AMPS) A	LOAD (AMPS) B	BKR. TRIP	WIRE SIZE	CKT. NO.	PHASE A B	CKT. NO.	WIRE SIZE	BKR. TRIP	LOAD (AMPS) A	LOAD (AMPS) B	LOAD SERVED
DRILL PRESS	6		20	12	1		2	12	20	6		DRILL PRESS
		6									6	
GRINDER	8		20	12	5		6	12	20	10		ARC WELDER
		8									10	
TABLE SAW	9		20	12	9		10	12	20	9		TABLE SAW
		9									9	
RADIAL ARM SAW	6		20	12	13		14	12	20	6		SANDER
		6									6	
BAND SAW	5		20	12	17		18	12	20	7		MASONRY SAW
		5									7	
PLANER	6		20	12	21		22	12	20	5		SHAPER
		6									5	
SPARE			20		25		26		20			SPARE
SPACE					29		30					SPACE
SPACE					33		34					SPACE
SPACE					35		36					SPACE
SPACE					37		38					SPACE
SPACE					39		40					SPACE
SPACE					41		42					SPACE
TOTAL	40	40								43	43	TOTAL

TOTAL CONNECTED AMPS A: 83 B: 83