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CFX ITS Inspection Reference & Training Manual

Chapter 8

Power Services

8.0 Introduction

This chapter details the standard types of electrical service equipment and its associated peripherals found throughout CFX's system. The CEI must ensure that every effort is being employed to verify that only knowledgeable and qualified individuals construct, inspect and maintain electrical elements of CFX's system. Proper care must be taken during electrical installations, inspections, and maintenance to ensure that all personnel are kept safe.

8.1 Overview of CFX Electrical Power Services

Electricity flows through the electrical system and its peripherals to provide power to ITS devices throughout CFX's system. This includes unregulated local power company service feeds, solar powered devices, generators, and Uninterrupted Power Services (UPS). As it relates to electrical service points from local power companies, ITS devices may have their own dedicated power service point or may share a power service point with other devices along the roadway. The determination of whether or not the ITS device site will have its own power service point is largely dependent upon the location of electrical distribution lines in the area and the cost of installing a new power service versus installing new conductors and infrastructure from an existing power source.

Power services must be designed and sized appropriately for the load that the ITS device site or sites will require. The power load is determined by the maximum amount of power that all the electrical components at the ITS device site or sites will use if all devices are working concurrently with additional overhead for future equipment/devices. All electrical equipment and associated peripherals must be constructed in adherence with the applicable CFX Power Service Assembly (A639) Technical Special Provisions, latest versions of NEC and NESC and any local power company requirements.

8.2 Electrical Components

The electrical system is comprised of several parts. These parts all work together to provide power to ITS equipment. CFX has created several electrical details which include: load centers (at the power company service point/drop), safety disconnects (at the ITS device pole) and associated wiring schematics that can be found in the latest edition of the ITS Design Standards and construction plans. CFX has also developed Technical Special Provisions for Power Service Assemblies (639A) that list and outline specific installation requirements, make and model of electrical equipment, as well as minimum criteria for peripheral equipment to support the electrical system.

8.2.1 Weatherhead – A weatherhead is part of the above-ground conduit system that is used to provide a weatherproof entry point for aerial service connections. The weatherhead must have a minimum of three electrical service entrance holes.

Figure 8.1: Weatherhead for a power service drop

8.2.2 Conduit – Conduit is used to protect electrical service, feeder and grounding conductors and can be of several different types, including PVC, HDPE, rigid metal, and liquid-tight flexible metal. For above-ground applications, use only hot-dipped galvanized steel and liquid-tight flexible metal conduit.

Figure 8.2: Power Service Site with Aboveground Rigid Metal and Flex Conduits

8.2.3 Conduit Ground Bushings – Ground bushings provide a smooth-walled surface to protect electrical conductors during installation and provide a dedicated ground lug to ensure that all metal portions of the electrical system are grounded. The terminating ends of all metal conduit must be furnished with a ground bushing.

Figure 8.3: Conduit Ground Bushing

8.2.4 Conductors – Conductors provide a pathway for electrical current from the electrical power source to the ITS device or a pathway for grounding applications. Conductors must be stranded copper conductor and XHHW (cross-linked polyethylene (XLPE) high heat-resistant, water-resistant) insulation, with a 45-mil thickness or greater, rated at 600V in dry and wet conditions.

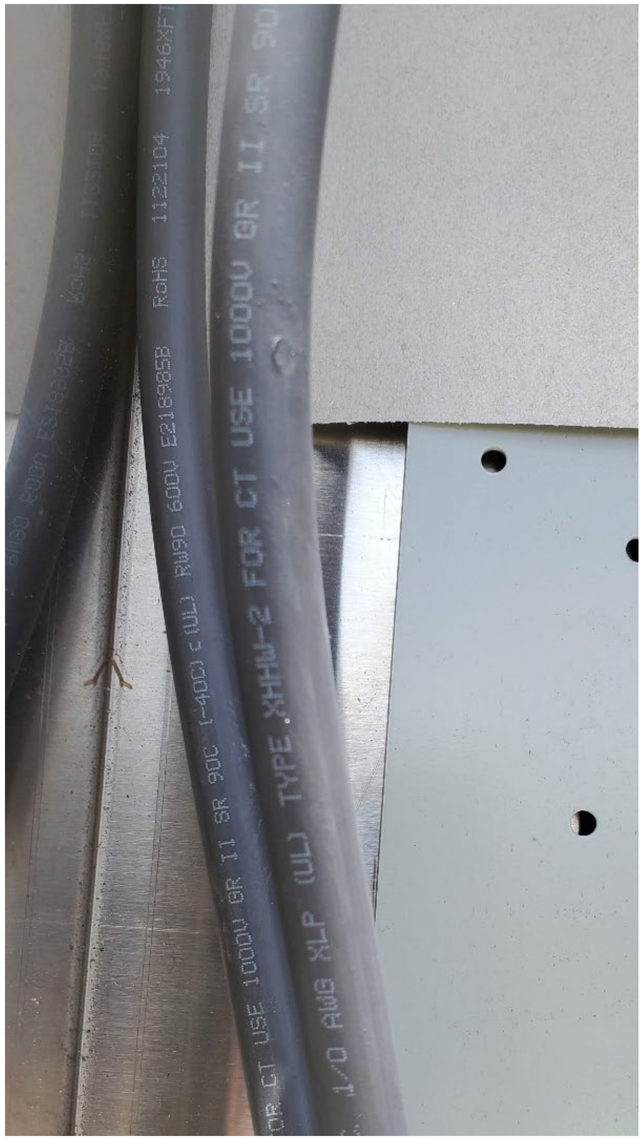

Figure 8.4: XHHW-2 Conductor

Electrical conductors must be sized in accordance with the plans and be no smaller than #6 AWG. CFX also requires, per Specification 639A-4.4.1, that only electrical service conductor (includes grounding conductors) that are either green, white, black, red, or blue in color be used. Green conductors must only be used to identify grounding conductors. White conductors must only be used to identify neutral conductors. Black conductors must be used to identify one phase of a power source and black is to be used as the default color when only one phase is being utilized. Red conductors may only be used to identify one phase in either single phase or three phase applications where two or more phases are being utilized. Blue conductors may only be used to identify one phase in three phase applications where three phases are being utilized. The use of any other color is strictly prohibited. Do not re-identify by wrapping colored tape around a conductor, called “phasing,” any conductor #6 or smaller. For electrical service conductors that are larger than #6 AWG, re-identification or “phasing” will be permissible only on black conductors, the “phasing” tape used must be either green, white, red, or blue.

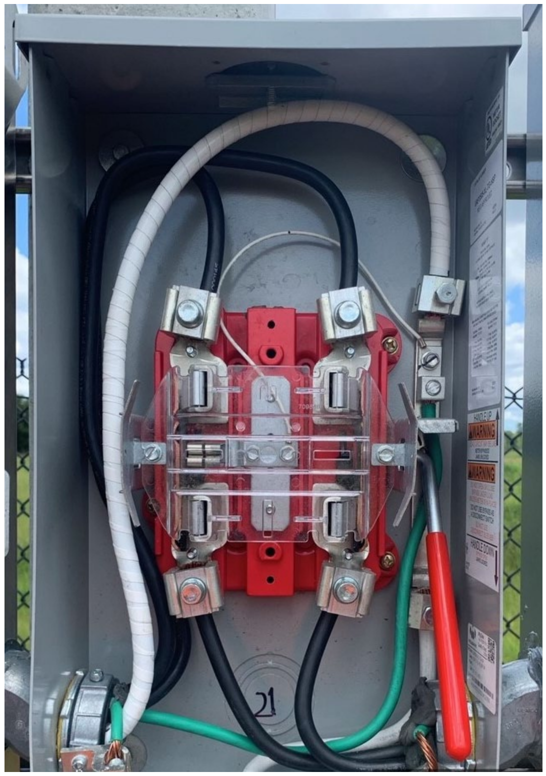

Figure 8.5: A White Phased Conductor

8.2.5 Meter – Meters are typically required throughout the system when establishing a new electrical service. Meters allow the power companies to monitor the use of electricity to a customer and provide a means for billing. All meters must be furnished with both a dedicated isolated neutral busbar and a dedicated grounding busbar with both having a minimum of eight positions and capable of accommodating the conductors sized in the plans and technical provisions. Meters must be approved for use by the electrical power company, rated for its intended use, and a permanent label must be riveted onto the meter with the approved street address.

Figure 8.6: Electric Meter for a CFX ITS Site

8.2.6 Disconnects – Disconnects provide a location within the electrical system for over-current protection or where the electrical power can be turned-off to safely work on ITS devices. All disconnects must be Square D, outdoor rated and properly sized for their use. All disconnects must have a ground busbar that is copper coated and has a minimum rating of 100 amps. The CEI must verify that the ground busbar has a minimum of eight spots and can facilitate the size of conductors as shown in the plans.

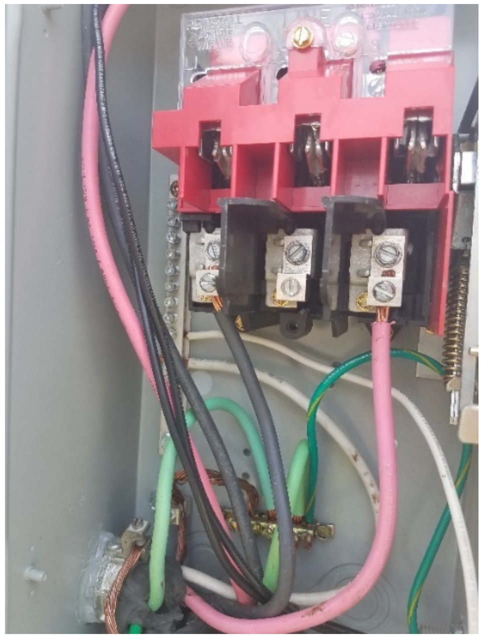

Figure 8.7: Electrical Disconnect internal view

8.2.7 Busbars – Busbars provide a location to land conductors within electrical enclosures. Within all disconnects, there must be a dedicated physically affixed grounding busbar – to connect the grounding conductors within the system and a dedicated isolated neutral busbar – to connect grounded conductors.

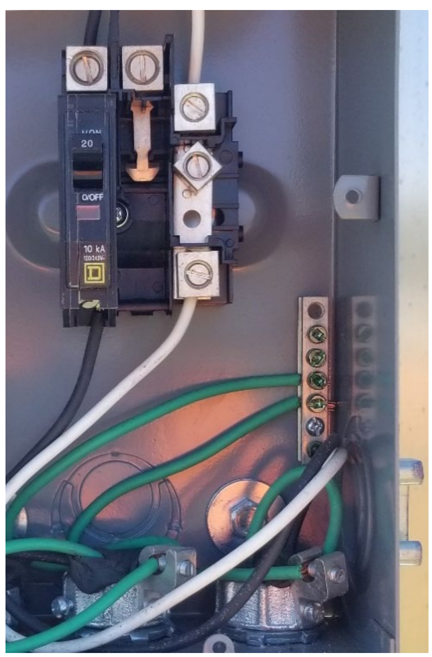

Figure 8.8: Ground Busbar

8.2.8 Circuit Breakers – Circuit Breakers are a means of over-current protection within the electrical system. Circuit breakers must be Square D manually resettable clamp-on type circuit breakers and sized correctly for their intended use.

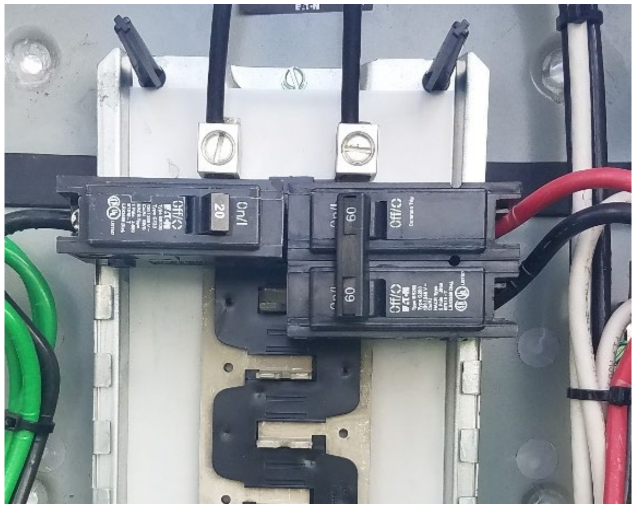

Figure 8.9: A Single pole and a Double Pole Breaker

8.2.9 Surge Protection Device – Surge protection devices provide a means of line-to-ground protection from voltage surges in the electrical system. Surge protection devices must be installed at all breaker panels and installed on the equipment (load) side of the disconnect. The surge protection device can be installed on the side or bottom of the breaker panel and must be on a separate breaker. Silicone sealant must be placed around the externally mounted surge protection device on both the inside and outside of the disconnect.

Figure 8.10: Main A/C TVSS

8.2.10 Transformers – Step up/step down transformers are used to increase or decrease the electrical voltage within the electrical system. Transformers provide a means to increase the voltage over a long distance while maintaining a smaller electrical conductor size and can reduce the need for a neutral conductor, providing significant cost savings. Only dry-type transformers conforming to NEMA 3R standards can be used. Reverse-fed transformers are not permitted for use on CFX projects. The picture below, shows a transformer installed at a power service. The transformer is the component to the right of the electrical panel.

Figure 8.11: Transformer shown at a power service – far right component (in this picture)

8.3 Electrical Installations

All work must be performed by qualified staff and be constructed to the latest versions of the NEC and NESC. Special care should be taken to ensure that equipment and electrical hazards are safeguarded against, and that proper Personal Protective Equipment (PPE) is utilized while working or inspecting energized electrical components.

8.3.1 Electrical Peripherals – All electrical and grounding conductors must be stranded copper conductors with XHHW insulation with a 45-mil thickness or greater and rated at 600V in dry or wet conditions. No conductors can be sized smaller than #6. All electrical splices must be made within a pull box or within transformers. Splices are not permitted within NEMA enclosure cabinets, Local HUBs, disconnects or breaker panels. When phasing or re-identifying electrical conductors larger than #6 AWG, the entire portion of the conductor that is visible within pull boxes, electrical equipment and cabinets must be fully and completely taped.

Figure 8.12: Red electrical phasing tape

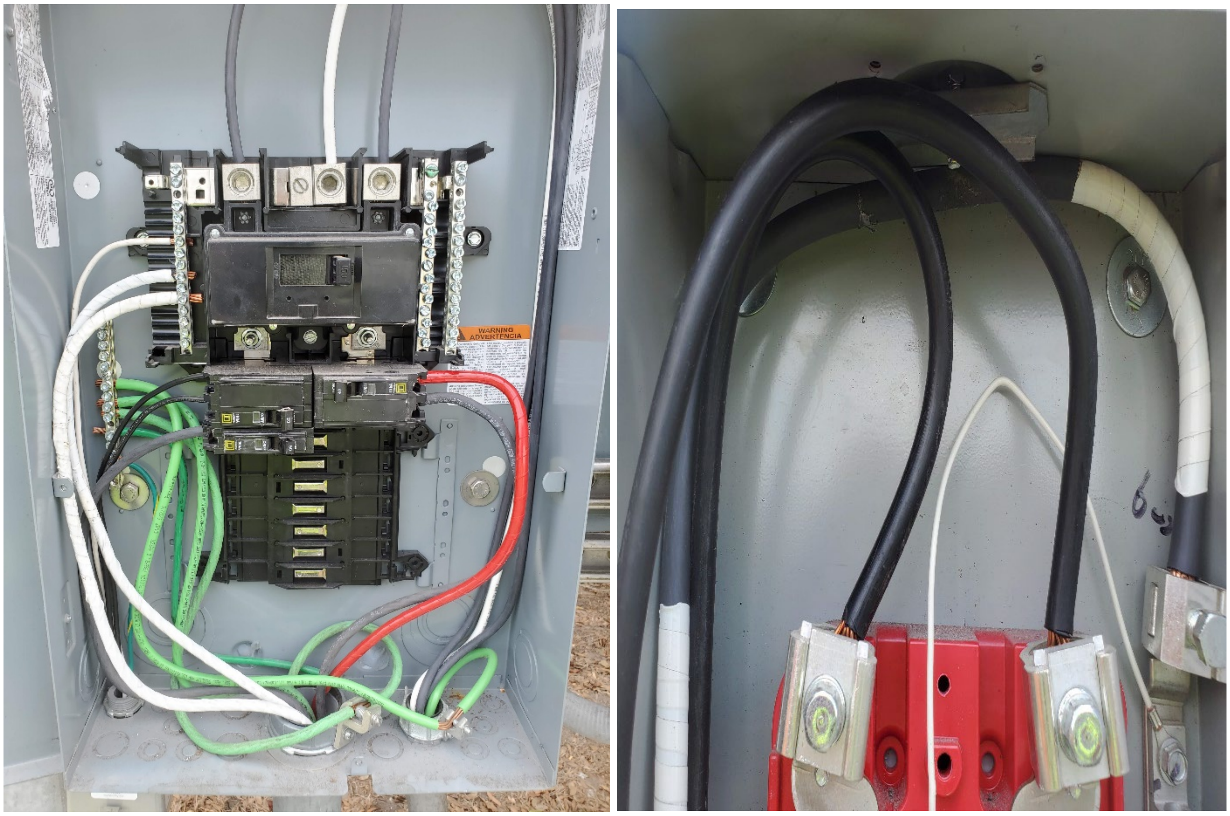

Figure 8.13: Fully Phased Conductors (correct) vs Partially Phased Conductors (Not Acceptable)

Install electrical conductors in a manner that ensures that damage to the insulation will not occur. When terminating conductors into terminal lugs, be sure that only the appropriate amount of conductor is exposed to minimize electrical shorts. Per NEC 110.14, only one conductor will be permitted within each terminal lug unless the terminal lug is identified (in clear writing) for such.

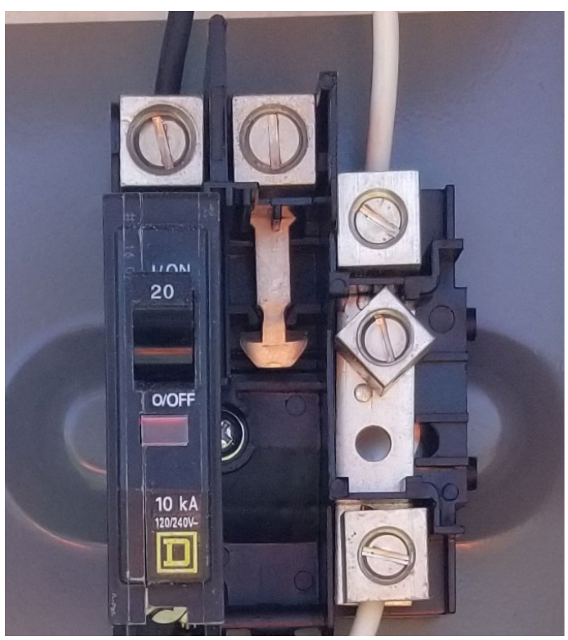

Figure 8.14: Terminal lugs with landed conductors

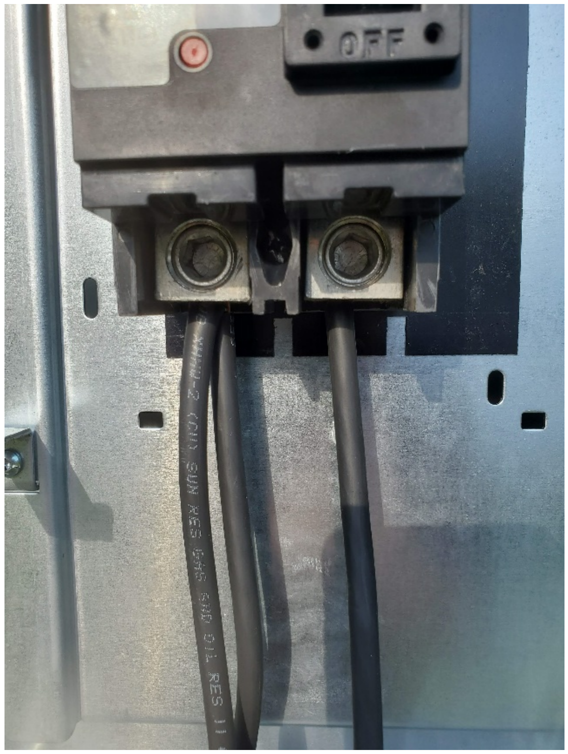

Figure 8.15: Double Tapped Lug (Not Acceptable)

Duct sealant must be provided within the ends of all conduits entering or exiting the electrical service equipment, pull boxes, cabinets, and the bases of ITS device poles to assist in preventing the ingress of moisture, dust, and insects. The threaded ends of all electrical conduits must be field galvanized to inhibit the formation of rust. All rust must be thoroughly removed with a wire brush and sprayed with cold-zinc galvanization spray. This work must be performed before any conduit painting (to match existing surfaces) is performed.

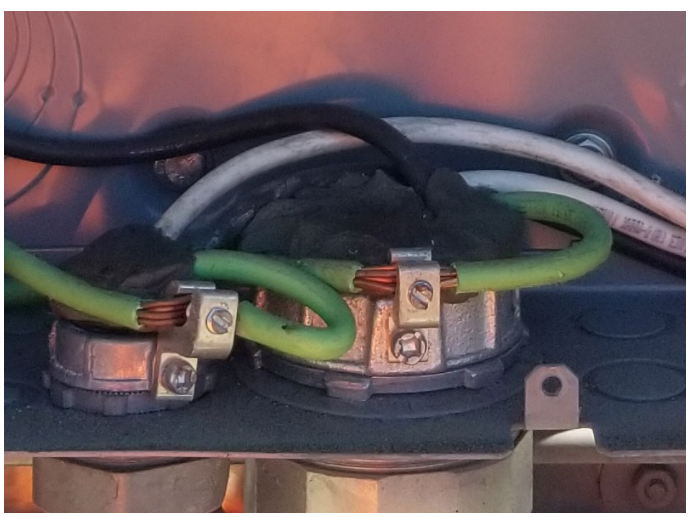

Figure 8.16: Duct Seal installed in Rigid conduit

Pull boxes must be installed along the conduit runs and at above ground to below ground transitions, as shown on the plans. Electrical grounding electrodes must be placed in pull boxes where electrical splices have been performed or at the ends of an electrical conductor run and an exothermic cadweld kit installed for grounding connections. The contractor is not to break out the electrical grounding conductor at all pull boxes as this unnecessarily creates additional points of failures within the electrical grounding system.

Neutral-ground bonds are required per the NEC and the power company and must be made at the first point of disconnect within the electrical system. Re-grounding the neutral conductor is prohibited and can cause an unnecessary additional path to ground. This additional path can cause electrical shock for technicians working on the grounding system between bonded neutrals. In the case where step-up/step-down transformers are used, and the neutral conductor has been eliminated and then re-established at the sub breaker panel (often referred to as a safety disconnect), a neutral-ground bond must be re-established at the sub breaker panel to ensure the neutral conductor is grounded at the point of establishment within the electrical system.

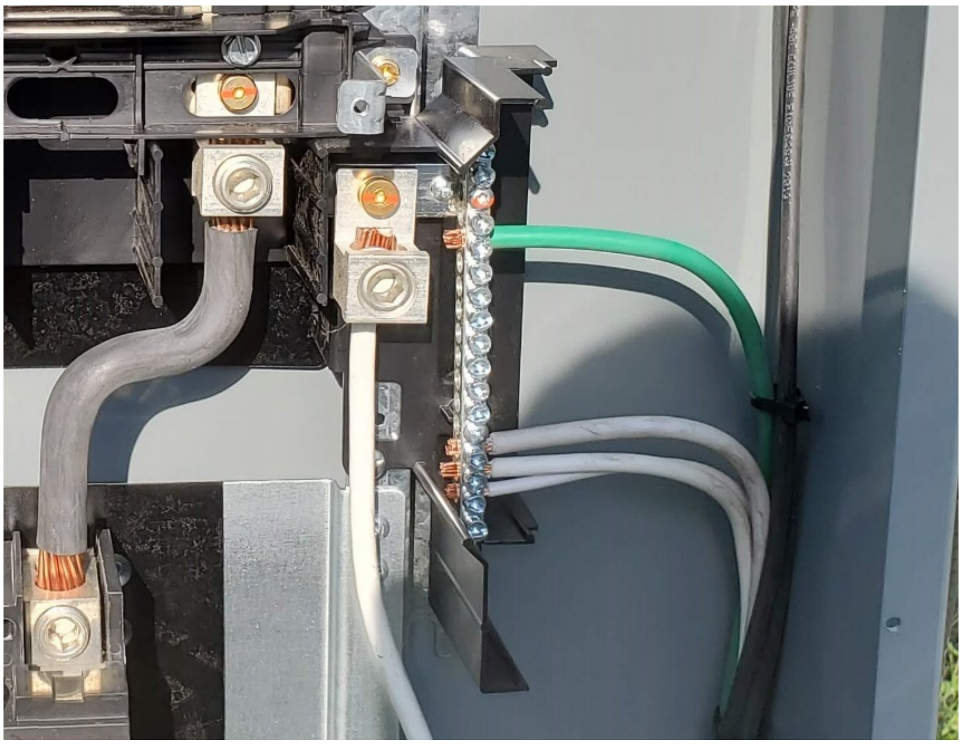

Figure 8.17: Neutral-Ground Bond

The main grounding busbar within the electrical service assemblies must be grounded to a dedicated grounding electrode specifically used for electrical systems. The grounding of the electrical system must be accomplished using a #2 solid tin-plated copper grounding conductor from the main grounding electrode installed at the base of the power pedestals within a pull box.

8.3.2 Electrical Service Assemblies – Electrical power service assemblies establish a location for the electric meter and a means of electrically disconnecting the ITS equipment connected downstream. Electrical power service assemblies consist of a concrete pedestal or pedestals with an H-frame assembly for mounting the electrical equipment. Sometimes, a line-side disconnect and step up/step-down transformer may be used depending on the provided voltage from the power company and the distance to the ITS device(s) being fed.

As discussed above, concrete service poles are used as a physical means to mount electrical service equipment. Often times, two concrete service poles are needed and then Unistrut is used to connect the two poles together, providing a larger surface area to mount equipment (commonly referred to as H-frame assemblies). Concrete foundations are needed for all concrete pedestals as well as concrete aprons. This provides technicians with a clean workable area to service equipment as well as protection for the electrical equipment from being damaged by landscaping and mowing activities.

Figure 8.18: Power Service Assemblies shown mounted on a concrete pole and an H-Frame

Conduit installed at electrical power service assemblies must be hot-dipped galvanized and installed in accordance with the Technical Special Provisions and the ITS Design Standards. Liquid-tight flexible metal conduit is permitted at electrical power service assemblies as long as the equipment is all housed on the same assembly and mounted to the same service pole(s). Ensure that the ends of all metal conduits are terminated with a conduit ground bushing. Provide a dedicated #6 stranded green grounding conductor with XHHW insulation to connect to all ground bushings within any electrical equipment or cabinet. This dedicated grounding conductor must be connected to a dedicated grounding busbar within each electrical equipment cabinet. This dedicated ground conductor can be used for no other purposes but to ground the ends of metal conduits.

Per OUC and Duke Energy standards, line-side disconnects are required at locations where the line-to-ground voltage is 480VAC or higher. These non-fused disconnects provide the maintainers an in-line location before meters, breaker panels and transformers to disconnect the electrical power and provide protection against higher-than normal working voltages. The line-side disconnects must be furnished with a dedicated isolated neutral busbar and a dedicated grounding busbar with a minimum of eight positions and capable of accommodating the conductors sized in the plans and technical provisions.

CFX requires the tops and sides of all electrical equipment be silicone sealed to prevent the intrusion of water. The bottom portion of the electrical equipment must not be sealed as this allows for any collected water to drain. Silicone seal all small openings smaller than 1/8”.

CFX requires that a dedicated #6 stranded green XHHW insulated grounding conductor be provided between all grounding busbars on the same electrical service pedestal or H-frame assembly. This ensures that all of the electrical equipment is grounded at the same potential. Use of this grounding conductor for the conduit ground bushings is not permitted.

The latest Design Standard Sheet for an Electrical Service Assembly Without a Transformer is shown on the following page.

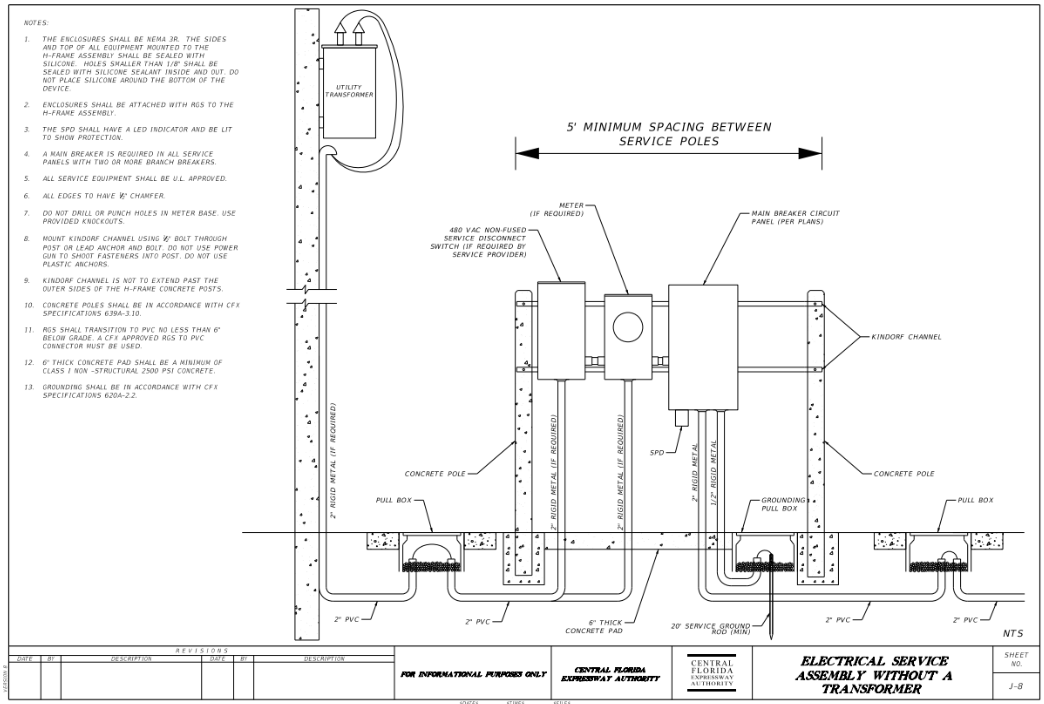

Figure 8.19: CFX Design Standard for an Electrical Service Assembly without a Transformer

8.3.3 Main Breaker Panels – Main breaker panels provide an over-current protection means and a point of disconnection of the electrical system. Main breaker panels are also a location to tie in multiple branch circuits, minimizing the needs for additional service points. The main breaker shall be sized appropriately and be at a higher over-current protection size than that of its branch breakers. Branch breakers provide over-current for specific circuits and are also used to connect surge protection devices. The main breaker panel must be furnished with a dedicated isolated neutral busbar and a dedicated grounding busbar with a minimum of eight positions and capable of accommodating the conductors sized in the plans and technical provisions. Clearly and permanently label the panel schedule within the breaker panel as to which ITS device is being supplied with power. Include the LHUB's milepost and direction of travel, at a minimum.

Figure 8.20: Main Electrical Panel for multiple ITS device sites

8.3.4 Safety Disconnects – Prior to electrical connection to local HUBs, CFX employs the use of safety disconnects which allow the technician the ability to disconnect the power to a specific site for safe working and a local means of over-current protection. Safety disconnects are typically mounted to a single concrete pedestal that has been installed with a concrete foundation and a concrete apron poured around the pole to provide the technician with a clean workable area to service the equipment as well as protection to the electrical equipment from being damaged by landscaping and mowing activities. All conduit ground lugs must be tied together utilizing a single XHHW, green insulated, #6 AWG stranded copper conductor and must be terminated on the ground busbar. Note that in the picture below, there are no conduit ground lugs and therefore this is an improper installation.

Figure 8.21: Internal view of a Safety Disconnect

8.3.5 Local HUBs – Local HUBs are installed at ITS device locations throughout the system. These HUBs are Type 336S or 334 cabinets and are described in detail in the cabinet chapter of this training manual.

Within every local HUB, there is an electrical panel that allows for the termination of electrical conductors. The electrical panel's main terminal lugs must be sized appropriately for the conductors to be installed. Special care should be taken to verify that no neutral-ground bonds are ever created within local HUBs and that the electrical ground is physically isolated from the lightning protection/low voltage grounding system.

Local HUBs are also provided with circuit breakers as a means of over-current protection and for the ability to disconnect the power for troubleshooting purposes. Under no circumstances should the breaker within the cabinet be at a higher amperage than that installed at the local HUB's safety disconnect.

All 336 and 334 Local HUBs are furnished with a separate high-end surge protection device that provides in-line protection for all connected equipment. A check of the LED indicator lights must be performed to ensure all conductors are protected.

Figure 8.22: ASCO surge protection device on main A/C lines into the cabinet

UPS circuits exist for all ITS devices throughout the system. Special care must be taken to ensure that the electrical conductors from this system, and the power company are isolated and housed in separate pull boxes or conduits.

8.4 Power Services Pre-Activity Considerations

1) Visual inspections of the electrical equipment with regards to conformance to the project's contract documents, and workmanship need to be performed prior to energizing any electrical service. Please note that all installations, inspections, and maintenance must only be performed by qualified individuals. All individuals must wear the appropriate PPE and the use of a Lock-out Tag-out (LOTO) kit must be installed prior to working on energized circuits.

2) All work must be coordinated with the respective project's CEI and the CFX ITS/Electrical Liaison. The contractor will self-inspect all work and once done, submit the self-inspection paperwork to the project's CEI for review. A formal inspection must be coordinated with the contractor, project CEI and CFX ITS/Electrical Liaison. The contractor must furnish all required contract documents and aide in the inspection. Once all deficiencies are corrected, the CFX ITS/Electrical Liaison will allow the contractor to request that the meter be energized.

3) A physical check of all electrical connections must be performed to ensure no loose conductors come free and create electrical shorts. A visual check must be performed on the ends of all conductor terminations to ensure that only the proper amount of insulation has been cut-back and that no copper strands were damaged or removed to facilitate cable terminations.

4) Once a visual check of all electrical components to ensure proper grounding has been performed, a multi-meter must be used to verify grounding continuity between all electrical components and the dedicated electrical grounding electrode. A three-point earth ground megger must be used at the dedicated grounding electrode in accordance with the grounding chapter of this training manual.

5) Perform a visual check of the surge protection devices to ensure that no physical damage is present and review all LED indicators to ensure that the device is in a "good" or "protected" state.

6) A physical check with a multi-meter must be performed to test the amount of induced voltage between the grounding and grounded conductors.

7) Visual checks should be done on the entire electrical system from Load Center/Electrical Power Service Assembly to the Local HUB. The breaker sizes must be decreased or kept the same from the point of service to the equipment site. If the breakers are reversed, the Load Center/Electrical Power Service Assembly site could have a 'tripped' breaker having technicians spending large amounts of time tracing out outages as well as potential extended time before an over-current protection device trips, within the system.