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CFX ITS Inspection Reference & Training Manual

Chapter 2
Conduit

2.0 CONDUIT INTRODUCTION

The purpose of conduit is to provide a protected pathway, or raceway, for electrical conductors and communications cables. Additionally, conduit provides a means of removing and replacing the product inside of the conduit, without the need to re-trench. There are numerous types of conduits, coming in a variety of materials, shapes, and sizes, used for different purposes in CFX's ITS infrastructure. All conduit installations on CFX's system must meet National Electric Code (NEC), CFX Technical Specification, and CFX ITS Design Standard requirements. These requirements will vary depending on the conduit type, application, and installation method. This chapter will provide an overview of conduit systems commonly utilized in CFX's ITS infrastructure. Specifically, we will cover the following topics: conduit size, conduit accessories, types of conduit, methods of conduit installation, and conduit installation details.

2.1 CONDUIT SIZE

Conduits come in a variety of sizes and the construction plans will designate a trade size for each conduit run. Conduit size is commonly specified by two designations: a nominal pipe size (NPS) for diameter based on inches and a Pipe Schedule or Size Dimension Ratio (SDR) for wall thickness. Figure 2.1 below illustrates three key concepts relating to conduit size: inner diameter, outer diameter, and wall thickness.

2.1.1 Inner Diameter (I.D.) - The I.D. is the width of the conduit opening or inside wall to inside wall.

2.1.2 Outer Diameter (O.D) - The O.D. is the width of the conduit from the outer wall to the outer wall.

2.1.3 Wall Thickness - The wall thickness is the width between the outer wall and inner wall or is given by the following: $\frac{O.D.-I.D.}{2}$

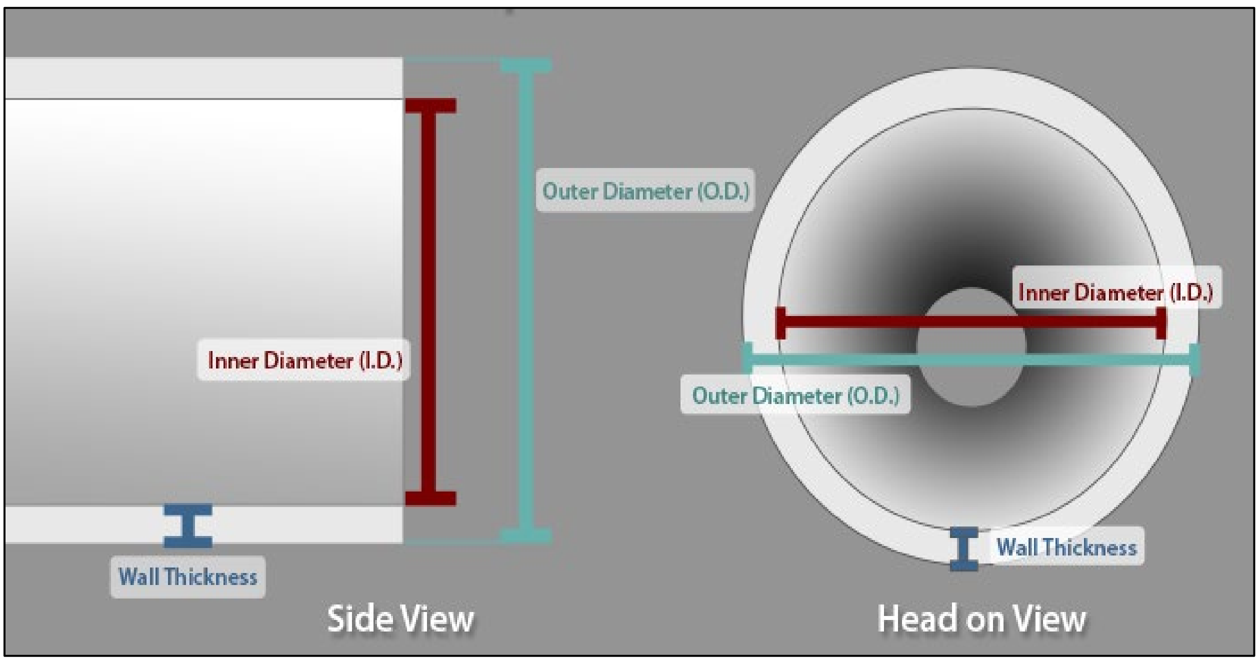

Figure 2.1: Conduit Dimensions

2.1.4 Size Dimension Ratio (SDR) – SDR is a value that is used for specific types of conduit and is defined as the ratio between the pipe's O.D. to the wall thickness and is used as a rating of a conduit's durability against pressure. An SDR 11 pipe means that the outer diameter is eleven times greater than the wall thickness. A high SDR means that the pipe wall is thin compared to the pipe diameter (lower-pressure rating), and a low SDR means the pipe wall is thick compared to the pipe diameter (higher-pressure rating). The outer diameter of a pipe is the same for all SDR in a particular trade size. Therefore, the inner diameter will increase as the SDR designation increases, due to a thinner wall thickness.

2.1.5 Pipe Schedule – Like SDR, Pipe Schedule is value used to describe the thickness of a pipe. Wall thickness increases as the Pipe Schedule designation increases. The outer diameter of a pipe is the same for all Schedules in a particular trade size. Therefore, Schedule 80 and Schedule 40 pipe will have the same outside diameter but since Schedule 80 pipe has a greater wall thickness the inside diameter will be less. A high Pipe Schedule means that the pipe has a high-pressure rating and a low Pipe Schedule means the pipe has a lower-pressure rating.

It is important to keep in mind that the conduit trade size does not actually reflect to the actual inner diameter or outer diameter of the conduit.

2.2 CONDUIT ACCESSORIES

There are many types of conduit accessories used in conduit systems to achieve the intended purpose of creating a protected pathway from the point of origination to the point of destination. This Section will introduce conduit accessories that are commonly encountered in conduit systems in CFX's ITS infrastructure. Keep in mind that this is by no means an exhaustive list of all conduit accessories that are available but instead is a representative list of accessories most frequently encountered in CFX's ITS infrastructure.

2.2.1 Coupling/Coupler – Couplings connect two sections of conduit to form a continuous path. Couplings are used to transition between conduit types and can be made of similar or dissimilar materials. Couplings used to transition from rigid conduit to flexible conduit are shown in Figure 2.2 below. Couplers are similar to couplings but are used to join two conduits of the same type together.

Figure 2.2: Coupling

2.2.2 Elbow – Elbows allow for a change in direction or bend in the conduit path of up to 90°.

Figure 2.3: Elbow

2.2.3 Bushing – Bushings are used at conduit termination points to an enclosure to provide a smooth pulling surface for pulling cables and conductors which minimizes chaffing. CFX requires the use of ground bushings, as shown in Figure 2.4, which also provides a means of grounding rigid metal conduit.

Figure 2.4: Ground Bushing

2.2.4 Locknut – Locknuts are required at rigid metal conduit termination points. They are used to secure conduit in place and prevent it from working loose over time.

Figure 2.5: Locknut

2.2.5 Nipple – A nipple is a short length of conduit used to extend a raceway or as a path between enclosures.

Figure 2.6: Threaded Nipple

2.2.6 Conduit Body – A conduit body is a separate portion of a conduit that provides access through a removable cover to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system. Conduit bodies are one of the most versatile components of a conduit system and can be used to facilitate cable pulling, inspection, maintenance, or to make bends in conduit systems.

Figure 2.7: LB Conduit Body

Figures 2.8 and 2.9 below demonstrate the use of conduit accessories at a conduit termination to a pole mounted ITS cabinet. Notice that in Figure 2.8, all conduits terminated at the enclosure are fitted with the appropriate size locknut to prevent the conduits from working loose over time as well as a grounding bushing, as appropriate.

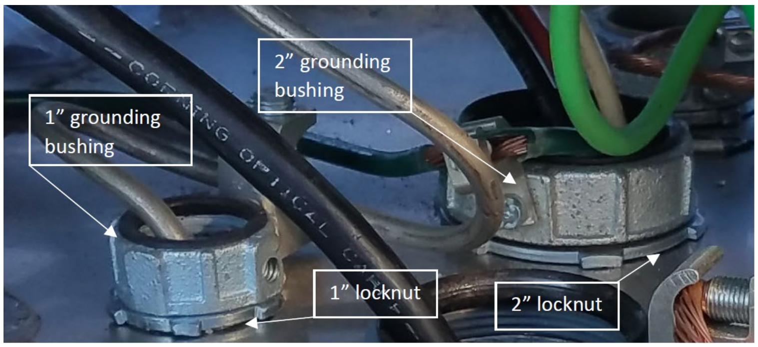

Figure 2.8: Conduit Accessories in Pole Mounted Cabinet

Figure 2.9 below demonstrates the use of nipples with a LB conduit body to create a protected pathway between the ITS device pole and the ITS device cabinet. Again, all conduit terminations are fitted with a locknut to prevent the conduits from working loose over time.

Figure 2.9: Conduit Accessories at Conduit Termination Point

2.3 TYPES OF CONDUIT

In addition to conduit size, the construction plans will also call for specific types of conduit depending on the intended use (e.g. electrical or communications) or by the application (e.g. underground or above ground). This Section will cover the various types of conduits used in CFX's ITS infrastructure and their allowable uses and applications.

2.3.1 Polyvinyl-Chloride (PVC) – PVC conduit is commonly referred to as "stick pipe" because it comes in sticks of 10-ft and 20-ft lengths. PVC conduit is identified by the Pipe Schedule designation discussed earlier in Section 2.2. There are two common types of PVC conduit used in ITS construction, Schedule 40 and Schedule 80. For a given trade size, 2" for example, both Schedule 40 and Schedule 80 PVC conduit will have the same outer diameter. The main difference is that Schedule 40 PVC conduit will have a smaller wall thickness and therefore a larger inner diameter than Schedule 80 PVC conduit. This difference is demonstrated in Figure 2.10 below. Joining these two types of conduit together shall only be done with an approved coupling for this specific use. If you join the two together using standard PVC couplers, cables could be chaffed during cable pulls.

Figure 2.10: Schedule 40 and Schedule 80 PVC Conduit

2.3.1.1 PVC Conduit Requirements – All PVC conduit installed in CFX's ITS infrastructure shall meet the requirements of CFX Technical Specification Section 638-2.6.2. CFX only allows the use of PVC conduit for underground conduit installations, above ground use of PVC conduit is strictly prohibited. All PVC conduit shall be Schedule 40 or Schedule 80, gray in color, and be manufactured with an integral bell on one end (as shown in Figure 2.11 below) and a machine end spigot on the other end. The bell and spigot allow PVC to be joined without the need for a coupler as shown in Figure 2.12 below. However, a coupling becomes necessary when PVC is cut to a specific size.

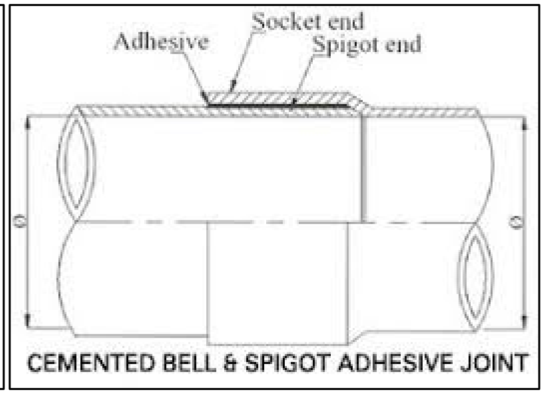

Figure 2.11: PVC Conduit w/ Integral Bell

Figure 2.12: PVC Pipe Joint

When joining two sections of PVC conduit, plastic solvent cement adhesive is applied to the spigot end per the manufacturer's recommendations. All PVC fittings shall be manufactured by the same process and of the same composition as the pipe and in accordance with the manufacturer's recommendations. Please note that PVC also can be crushed under weight and stress.

2.3.2 High-Density Polyethylene (HDPE) – Unlike PVC, HDPE conduit comes on a spool in continuous lengths as shown in Figure 2.13 below. HDPE conduit is identified by the Size Dimension Ratio (SDR) designation discussed earlier in Section 2.2. HDPE conduit is typically utilized for communications conduit throughout the industry due to the smooth inner wall allowing for easy installation of fiber optic cable.

Figure 2.13: HDPE Conduit Spool

2.3.2.1 HDPE Conduit Requirements – All HDPE conduit installed in CFX's ITS infrastructure shall meet the requirements of CFX Technical Specification Section 638-2.6.1. HDPE conduit can be used in electrical applications but is required for communications conduit runs. CFX requires all HDPE conduit to have an SDR of 11.

HDPE conduit installed for electrical conduit runs will typically be 2" and must be gray in color. HDPE conduit installed for fiber optic communications conduit runs will typically be 1" and must meet the following conduit color code format from CFX Technical Specification Section 638-2.6.1.2:

(1) **Backbone:** Orange, blue, brown, green, white, black, yellow, red w/ gray stripe and black w/ red stripe

(2) **Lateral:** Orange, blue, brown, and green
(3) **Drop:** Orange, blue, and black w/ red stripe

When making HDPE-to-HDPE connections, CFX requires the use of electrofusion couplers, as shown in Figure 2.14 below, manufactured by Central Plastics Company or a CFX approved equivalent. Electrofusion couplers have small copper wires embedded within the interior of the fitting. Electric current is applied to the small copper wires creating heat, which in turn melts the HDPE on the inside and outside of the fitting creating a homogenous bond and leak free joint, maintaining the smooth inside wall.

Figure 2.14: Electrofusion Coupler

2.3.3 Rigid Galvanized Steel Conduit (RGS) – Like PVC conduit, RGS comes in sticks of 10-ft and 20-ft lengths. RGS provides the most mechanical protection for conductors or cable due to the material strength and wall thickness. For this reason, CFX requires most above ground conduit installed in ITS applications to be RGS with transitions from underground PVC or HDPE to RGS conduit occurring a minimum of 6” below grade.

2.3.3.1 RGS Requirements - All RGS conduit installed in CFX’s ITS infrastructure shall meet the requirements of CFX Technical Specification Section 638-2.6.5. This article requires RGS conduit to be UL 6 rated, hot-dipped galvanized, with both ends reamed and threaded. Figure 2.15 below shows an example of RGS conduit transitioning from underground to terminate the raceways at an ITS device location. You can see that RGS conduit can be bent or cut in the field to meet the field conditions at a particular location. All field-threaded ends shall be re-galvanized before installation. All rust is to be removed and cold-sprayed.

Figure 2.15: RGS Entering ITS Cabinets

2.3.4 Liquid-Tight Flexible Metal Conduit (LFMC) – LFMC conduit is defined as a raceway of a circular cross-section having an outer liquid-tight, nonmetallic, sunlight-resistant jacket over an inner flexible metal sheath as shown in Figure 2.16 below. LFMC conduit is the one exception to the rule requiring that all above ground installations be RGS conduit. CFX allows the use of LFMC conduit at conduit corners or other transitions in above ground installations from ITS enclosures up to the ITS device location, only when all components are on the same assembly or pole. LFMC conduit can be used in both electrical and communications raceways. All LFMC conduit installed in CFX's ITS infrastructure shall be either gray or black. All transitions from RGS to LFMC conduit shall be made using the appropriate connectors as shown in Figure 2.17 below.

Figure 2.16: LMFC Conduit

Figure 2.17: LMFC Connector

2.3.5 Bullet-Resistive Fiberglass (BRFG) Conduit – BRFG conduit comes in 20-ft lengths and has the highest strength to weight ratio of any conduit material available allowing it to provide anti-theft uses. BRFG conduit also provides additional protection for the cable to prevent tampering or vandalism and when installed properly allows the raceway to withstand constant vibrations experienced from the bridge structure. It is also better suited for weather conditions and rusting. CFX uses BFRG conduit for bridge crossings, instead of rigid metal conduit, due to these advantages.

2.3.5.1 BRFG Conduit Requirements – All BRFG conduit installed in CFX's ITS infrastructure shall meet the requirements of CFX Technical Specification Section 638-2.6.3. BRFG shall have a 6" outer diameter and be gray in color but may need to be painted depending on its mounting location. BRFG conduit shall come manufactured with an integral wound bell on one end, or a bonded-on coupling and machine end spigot on the other end. All fittings and accessories utilized with BRFG conduit shall be manufactured using the same process and as recommended by the BRFG conduit manufacturer.

A 6-in expansion joint suitable for use with BRFG conduit is required on all bridge-attached BRFG conduit conduits at intervals not to exceed 100-ft. Hot-dipped galvanized steel bridge hangers meeting the requirements of CFX's ITS Design Standards shall be used to support the BRFG conduit at intervals not to exceed 10-ft as shown in Figure 2.18 below.

Figure 2.18: BRFG Conduit Hangers

2.4 INSTALLATION OF CONDUIT

Whether a conduit run is underground or above ground will dictate the type of conduit used and the installation method. It is common for a conduit run to have both underground and above ground sections so the conduit material used may change midway through the run (6" below grade). The type of conduit installation will vary depending on multiple factors such as terrain, soil conditions, presence of landscaping, presence of existing utilities or other obstructions, and length of the run. This Section will cover conduit installation methods and requirements for the different types of conduit systems utilized in CFX's ITS infrastructure.

2.4.1 Underground Conduit – Most of the conduit installed on CFX's system is underground as this provides the most protection and raceways need to extend from location to location along CFX's roadways. PVC and HDPE are the types of conduits that are utilized in these underground installations. All underground conduits must be installed according to the details in the plans, CFX's ITS Design Standards, and CFX's Technical Specification Section 638 which we will review in this Section.

2.4.1.1 Trenching – Open trenching is a method of underground conduit installation where the ground is opened up along the proposed path to create a trench for the conduit installation. Trenching can be accomplished by hand digging or by the use of machinery such as a mini-excavator as shown in Figure 2.19 below. Hand digging is required in locations where the trench will cross another utility at a similar depth and when in locations that contain landscaping and/or landscaping materials. The conduit is then uncoiled or laid directly in the open cut at the desired depth below grade. Trenching operations cause the most disturbances to existing conditions of all of the conduit installation methods.

Figure 2.19: Open Trench Operation

2.4.1.2 Plowing – Plowing is a method of conduit installation where conduit is installed through the use of specialized equipment. A plow machine that is equipped with a vibrating blade as shown in Figure 2.20 below cuts a trench ahead of a metal chute and placed the conduit in the ground at the desired depth. Plowing allows for long continuous runs of conduit installation, has the lowest installation cost relative to other methods, causes minimal disturbances to existing conditions, and is extremely effective in open areas. However, when there a lot of utilities or obstructions along the proposed conduit path, the use of a plow becomes less practical without proper site investigation and planning.

Figure 2.20: Plowing Operation

2.4.1.3 Minimum Depth for Trenched/Plowed Conduit – All trenched or plowed conduit shall require a minimum depth of 36” below finished grade (or 36” below the bottom of the roadway base layer when installing under future paved roadway) unless otherwise stated in the plans. Figure 2.21 below shows the typical cross section detail for all trenched and plowed conduit being installed for CFX’s ITS infrastructure. In situations where a depth of 36” can’t be achieved, additional mechanical protection such as concrete encasement shall be provided as outlined in CFX Technical Specification 638-3.2.7 Minimum Cover. This also requires the CEI Engineer’s approval.

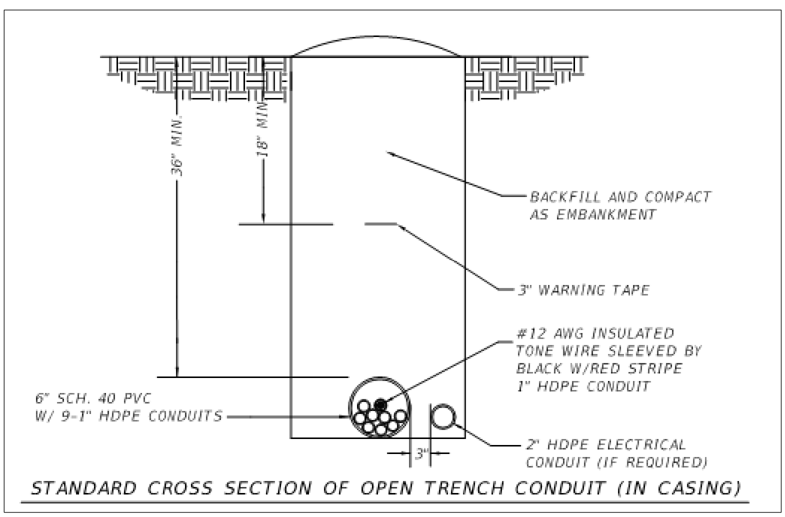

Figure 2.21: Plowing Operation

2.4.1.4 Backfill and Restoration – Trenches must be backfilled on the same working day and require compaction to a firm and unyielding state. Ensure all trenches are wide enough to allow for mechanical compaction equipment to meet this requirement. Additionally, conduit paths for both trenched or plowed conduit shall be restored to original or improved conditions, which include the replacement of any disturbed sod and landscaping with the original type of turfgrass or mulch. It is important that the CEI and contractor take the time prior to proceeding with these operations to document existing conditions along the proposed conduit path.

2.4.1.5 Warning Tape – Orange 3” fiber-optic warning tape with the words “CAUTION CFX FIBER OPTIC CABLE BURIED BELOW” printed at 1-foot maximum intervals is required at a depth of 18” below grade (or 18” below stabilized subgrade when installing under future paved roadway) along all trenched or plowed conduit paths. Fiber optic warning tape shall meet the requirements of CFX Technical Specification 638-2.6.7.

Figure 2.22: CFX Fiber Optic Warning Tape

2.4.2 Directional Boring – Directional boring or horizontal directional drilling (HDD) is a trenchless method for installing conduit in which a drill rig, as shown in Figure 2.23 below, is used to drill a pilot borehole along the predetermined path. A back reamer if then used to enlarge the pilot hole to the desired diameter to accommodate the proposed conduits. The proposed conduits are then pulled back through the drilled space. Drilling fluid (typically polymer or bentonite slurry) is used throughout this process to lubricate and stabilize the bore path.

Boring is more expensive than trenching or plowing on a per-foot basis but much less invasive, making it beneficial when aesthetics are important or when obstacles, such as roadways, sidewalks and landscape beds lie within the proposed conduit path, or when the terrain makes trenching operations impractical. Boring operations must adhere to the requirements of Section 555 of CFX’s Technical Specifications.

Figure 2.23: Directional Bore Operation

2.4.2.1 Minimum Depth for Bored Conduit – Bored conduit shall maintain a minimum depth of 48” below-finished grade (or ten times the bore diameter, or 60” whichever is greater, when underneath the roadway) as shown in Figure 2.24 below unless otherwise stated in the plans.

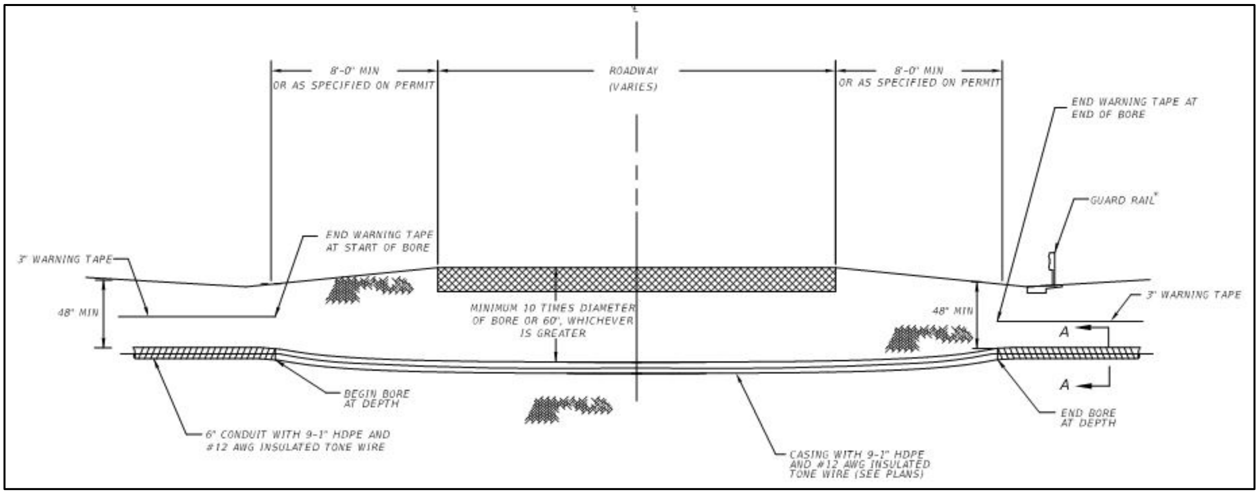

Figure 2.24: Required Bore Depth

2.4.3 Conduit Installation Depth Checks – It is important that the CEI spot checks conduit installation depths on a daily basis to ensure desired depth is being achieved. Figure 2.25 below shows an example of conduit that was installed at an inadequate depth leading it to be exposed at a later date when the area was graded for a future project.

CFX roadways are subject to future construction, such as widening to add additional capacity, therefore it is imperative that the CEI ensures that adequate depth is being achieved to ensure the conduit remains adequately protected in future projects or from other underground work activities. If conduit is being installed before an area is at final grade, it is important that the CEI and contractor come back to verify the depth to the conduit once the area has been graded. Below is a list of depth checks by conduit installation method that should be happening on a daily basis:

- **Open Trench Operation** – Measure trench depth using a measuring tape
- **Plowing Operation** – Use a probe rod or pothole
- **Directional bore operation** – Verify readings on bore contractor's locater
- **Final verification** – Check reading on locater utilizing CFX's Locate Management System (LMS)

Figure 2.25: Conduit Installed at Inadequate Depth

2.4.4 Protection of Conduit – CFX employs a few methods of additional mechanical protection for conduit runs in locations where the proposed conduit is vulnerable and may be susceptible to damage such as at bridge crossings, drainage structure crossings, areas where proper depth cannot be achieved due to obstructions and runs underneath of guardrail, roadways or driveways.

2.4.4.1 Outer Duct - CFX utilizes outer duct, where smaller HDPE conduits (inner duct) are installed in a larger HDPE conduit (outer duct) as shown in Figure 2.26 below. Outer duct conduit shall be HDPE SDR 11 and gray in color in accordance with CFX Technical Specification 638-3.1.3. It is common for CFX to utilize a 6” outer duct conduit with 9-1” inner ducts for their main backbone conduit system for their fiber optic network (FON) which will be discussed in more detail in Chapter 6. Note that CFX requires that the openings between the outer duct and inner duct conduits be sealed with non-shrink grout or expandable foam sealant in accordance with CFX Technical Specification 638-2.6.3.11.

Figure 2.26: Outer Duct and Inner Duct

2.4.4.2 Black Steel Pipe (BSP) – CFX commonly specifies the use of Schedule 80 BSP as a means of achieving additional mechanical protection of conduits when desired. BSP is most commonly used when conduit is placed underneath a guardrail (or future guardrail location) or around obstructions or existing proposed utility duct banks. BSP installed on CFX projects shall be in accordance with CFX Technical Specification 638-2.6.4.

2.4.4.3 Split Black Steel Pipe (SBSP) – SBSP is utilized at locations where additional mechanical protection of conduits is desired but the use of standard BSP is not practical. SBSP is manufactured with two seams such that it comes in two separate pieces and can be placed around existing infrastructure and clamped or bolted together. The most common situation where this occurs is when a section of existing conduits needs additional protection because a SBSP can be installed around the conduits while they remain in place. Additionally, when there are conduits that are already occupied by conductors or cable, SBSP can be installed around the exposed conductors or cable to protect them, which also serves as an acceptable means of conduit repair.

2.4.5 Conduit Bends – The number of bends in a conduit system is an important concept to keep in mind during conduit installation operations. If there are too many bends in a conduit system without an access point, the contractor can run into issues when attempting to install conductors or cables. For this reason, NEC Article 358.26 sets the 360-degree bend rule by requiring that there shall not be more than four quarter bends (360 degrees total) between pull points, for example, conduit bodies and pull boxes.

CFX’s Technical Specifications set a more stringent requirement than NEC by requiring the following:

- no more than cumulative 270° of bends or offsets
- minimum bending radius of 20 feet unless otherwise shown in the plans

- individual bends shall not exceed the minimum bend radius of a 72-strand single-mode fiber optic cable

2.4.6 Tubular Route Markers – CFX utilizes tubular route markers to indicate the path of electrical and fiber conduit installed as part of CFX's ITS infrastructure. Electrical or fiber route markers at all locations meeting the following requirements, as outlined in 638-3.2.17 of CFX's Technical Specifications:

- intervals not to exceed 4,000 ft for fiber conduit
- intervals not to exceed 500 ft for electrical conduit
- locations where conduit changes directions
- at each end of a directional bore
- at all pull boxes and vaults not installed in the pavement
- at locations as shown in the plans

Tubular route markers shall be made of HDPE and manufactured by Vulcan Utility Signs and Products or CFX approved equivalent, having a 3½ inch O.D. post, 6-foot length, and minimum wall thickness of 0.125 inches. An orange HDPE cap with black-on-orange "WARNING BURIED FIBER OPTIC CABLE" wrap decal shall be used to designate fiber as shown in Figure 2.27 below whereas a red HDPE cap with black-on-red "WARNING HIGH VOLTAGE POWER" wrap decal indicates power conduit as shown in Figure 2.28 below. Both CFX and Sunshine State One Call of Florida contact numbers shall be printed on the cap in black polyvinyl.

Figure 2.27: CFX Fiber Route Marker

Figure 2.28: CFX Power Route Marker

2.4.7 Above Ground Conduit – Above ground conduit is common at power service locations, ITS device locations where conduit enters a pole-mounted cabinet, and at bridge crossings. As previously mentioned in this Chapter, most above ground conduit installed in CFX's ITS infrastructure is RGS, except where LFMC is appropriate. In all cases, a CFX approved RGS to PVC connector will be used to transition from underground PVC conduit to RGS conduit. CFX requires all transitions of RGS to PVC to be no less than 6" below grade. This requirement is necessary to protect cables from vandalism or common hazards such as lawnmowers, which commonly hit above ground conduit installations potentially exposing live electrical or communications cables.

2.4.7.1 Securing and Supporting – All above ground conduit must be adequately secured and supported by appropriate means. For the purposes of this training, we will define securing and supporting as follows:

- **Securing** – fastening by mechanical means to prevent movement of conduit in the *horizontal* direction

- **Supporting** – fastening by mechanical means to preventing sagging or movement of the conduit in the *vertical* direction

NEC Article 344.30 requires above ground RGS conduit to be securely fastened at intervals not to exceed 10-ft and not more than 3-ft from an enclosure, box, fitting, etc. CFX Technical Specification 638-2.6.5 actually enforces a more stringent requirement requiring the use of conduit straps to secure RGS conduit at 5-ft centers. Proper securing of above ground conduit is typically achieved through the use of minerallac or two-hole conduit straps as shown in Figures 2.29 and 2.30 below, respectively. These conduit straps will be used to physically fasten the raceway to a structural member such as an upright such that the conduit does not move horizontally as shown in Figure 2.31 below.

Figure 2.29: Minerallac Conduit Strap

Figure 2.30: Two-Hole Conduit Strap

Supporting of horizontal conduit runs is most common in truss mounted RGS conduit at an ITS device location, bridge mounted BRFG conduit, and wall mounted RGS conduit runs. Horizontal conduit supporting requirements for these applications is achieved as follows:

- **Truss mounted RGS conduit** – Beam clamps as shown in Figure 2.32 are used to fasten the RGS conduit to the truss cross members at distances not to exceed 10-ft
- **Wall mounted RGS conduit** – Conduit straps are used to anchor the RGS conduit to the wall at distances not to exceed 5-ft
- **Bridge-mounted BRFG conduit** – Hot-dipped galvanized bridge anchors as shown in in Figure 2.33 below are required at distances not to exceed 10-ft as discussed in the BRFG Conduit Requirements Section earlier in this Chapter

Figure 2.31: Properly Secured Above Ground RGS Conduit

Figure 2.32: Beam Clamp

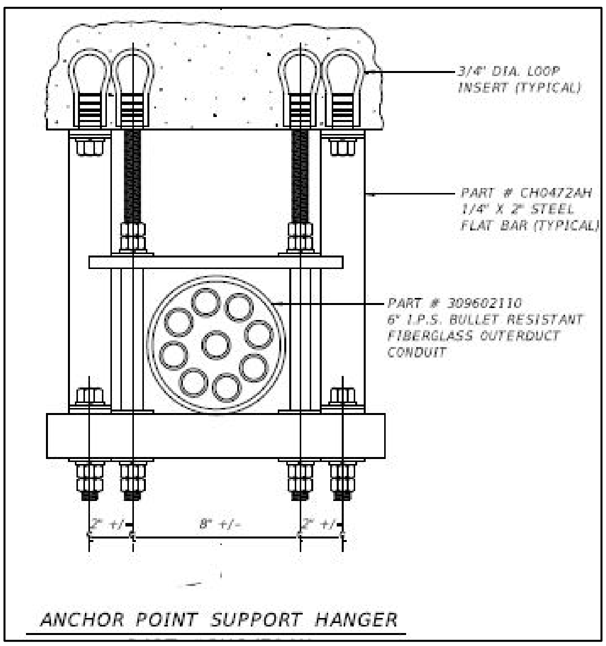

Figure 2.33: Bridge Anchor

2.4.8 Sealing – Sealing of conduit systems is an important step to ensure the raceways remain protected from the intrusion of dirt and foreign materials, thereby providing protection for the conductors or cables housed inside or preserving the spare ducts for future use. CFX Technical Specification 638-3.2.14 outlines the following sealing requirements for conduit systems:

- **Electrical conduit** – All electrical conduit, less than 100 feet in length, housing power conductors are to be sealed with an oil-based RoHS compliant duct seal as shown in Figure 2.34 below.

Figure 2.34: Properly Sealed Electrical Conduit

- Copper Keepers - CFX Technical Specification 638-3.2.19 requires the use of Copper Keeper™ Cable Security System for all conductor installations extending a distance greater than 100 feet. The Copper Keeper™ is a rubber stopper manufactured with four conductor pockets. The Copper Keeper™ is further detailed in Chapter 4, Conductors.
- **Communications conduit** – All spare 1" HDPE communications conduit shall be sealed with Carlon duct plugs model number(s) MAEPG2 through MAEPG7 (or CFX approved equivalent) as shown in Figure 2.35 below. Figure 2.36 below shows appropriately sealed spare communications conduit at a termination to a fiber optic manhole. These plugs have a compressed seal that expands into full contact with the inside pipe walls, thereby providing an effective, permanent, positive seal to the conduit system.

Figure 2.35: Carlon Duct Plugs

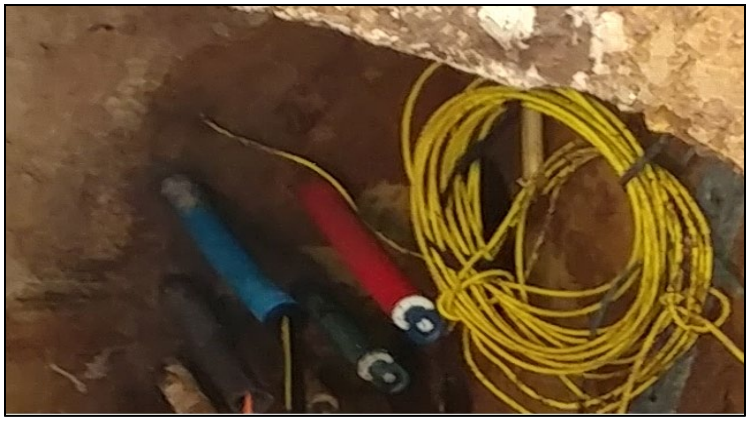

Figure 2.36: Properly Sealed Communications Conduit

- **Outer duct** – All outer duct openings around 1" HDPE inner duct conduits shall be sealed with a non-shrink grout or expandable foam sealant listed on the FDOT's Approved Products List (APL).

- **Spare 6" conduit** – Spare 6" conduits shall be sealed with Carlon duct plug model number P258RT (or CFX approved alternate) as shown in Figure 2.37 below.

Figure 2.37: Carlon Duct Plug Model P258RT

- **Spare 8" conduit** – Spare 8" conduits shall be sealed with HVAC Express duct plug model number P258RT (or CFX approved alternate) as shown in Figure 2.38 below.

Figure 2.38: HVAC Express Duct Plug Model FC 8

2.5 PRE-ACTIVITY CONSIDERATIONS

This Section will serve as a checklist of items that the CEI and contractor shall follow prior to proceeding with conduit installation on CFX projects:

1) **Initial Site Review -** The CEI and contractor shall schedule a joint review of the proposed conduit paths to review the plan requirements, this meeting is ideally held in tandem with the CFX FON and lighting handover meeting where these facilities are located by CFX representatives. At the initial site review meeting, the number, sizes, and types of proposed conduits shall be discussed. The CEI and contractor shall thoroughly document existing site conditions, noting any existing infrastructure, grassed or landscaped areas that may be impacted by the conduit installation. It is also recommended that the CEI and contractor meet with all utility owners that have facilities within the area of the proposed underground conduit installation to resolve any conflicts with their facilities.

2) **Review of CFX's FON GIS Database -** During the joint site review meeting, the CEI and contractor shall reference CFX's FON GIS database to verify there are no discrepancies between the approved for construction plans and the existing conditions of CFX's FON infrastructure in the field. The CEI and contractor shall be in the habit of referencing CFX's FON GIS database on a daily basis when performing conduit installation to help mitigate impacts to CFX's FON. Any discrepancies identified during the joint review meeting or during an ongoing conduit installation operation shall be promptly escalated and resolved before proceeding.

3) **Comparison of Locates** - During the joint site review meeting, the CEI and contractor shall compare the locate flags to the utilities shown in the construction plans. Any unmarked utilities shown in the plans or discrepancies between utilities shown in the plans when compared to the locates in the field shall be discussed and resolved with the proper Utility Agency / Owner.

4) **Review of Proposed Conduit Path** - During the joint review meeting, the CEI and contractor shall review the proposed conduit path shown in the plans and determine based on the results of the Initial Site Review, Review of CFX's FON GIS, and Comparison of Locates, if there is a more appropriate route for the proposed conduits, that conflicts less with existing utilities, landscaping, or other infrastructure. A general plan shall be agreed upon for all conflict points along the proposed conduit path where an existing utility or drainage structure must be crossed. Any conflict points shall be documented and white lined accordingly.

5) **Sunshine OneCall Verification** - It is the responsibility of the contractor to follow Florida Statute 556, The Underground Facility Damage Prevention and Safety Act, for any excavation or underground work operations. This requires the contractor to submit locate tickets through the Sunshine OneCall (811) system and receive positive responses from all Utility Agencies / Owners prior to proceeding with underground work. The CEI shall verify on a daily basis that the contractors locate tickets are cleared and the locates are visible in the field in the area the work is to be performed.

6) **Documentation of Locates -** Prior to commencing with underground conduit installation each day, the CEI shall take video or photo documentation of the locate flags along the proposed conduit path. This is in an effort to show that all facilities were appropriately marked in the field, in the event of a utility hit.

7) **Protection of Existing Utilities** - The CEI shall ensure that the contractor is exercising appropriate caution when performing underground work in the vicinity of an existing utility. The CEI, if the contractor is not already doing so, shall direct the contractor to pothole the existing utility every 50 ft when the proposed conduit is being installed parallel to and near an existing utility. Anywhere the proposed conduit gets within a 2-foot window of an existing utility, the CEI shall ensure the contractor properly exposes that utility in accordance with F.S. 556 before proceeding with the conduit installation.

8) **Depth Checks –** The CEI shall spot check that adequate conduit installation depths are being achieved on a daily basis. If conduit is being installed prior to the project being at final grade, the CEI shall confirm that the conduit is still at an adequate depth once the area has been graded.

9) **As-Built Conduit Path** – The CEI and contractor shall as-built the actual conduit path on a daily basis as the conduit is being installed. Any changes in the number or size of conduits or deviations from the conduit paths shown in the plans, shall be redlined in the as-built plans.