

CHAPTER 7

TRAFFIC SIGNAL DESIGN – PULL BOXES, CONDUITS, AND WIRING

7.1 Pull Boxes

A pull box is an underground compartment made of various materials, such as pre-cast concrete or polymer concrete (composite). When possible, pull boxes should be located adjacent to the sidewalk rather than in the sidewalk. Pull boxes used in traffic signal installations shall meet current TDOT standards and specifications (See TDOT Standard Drawing T-SG-2). The purpose of pull boxes is:

- To provide access to underground detectors and interconnect cables;
- To provide locations to consolidate separate runs of signal and detector cables;
- To provide locations to facilitate the pulling of long runs of detector or interconnect cables;
- To provide locations to store spare lengths of signal detector or interconnect cables.

7.1.1 Type/Size/Use of Pull Boxes

TDOT Standard Drawing T-SG-2 shows the various pull box sizes and their normal application or use. Type A Pull Boxes should be used exclusively for splicing loop wires to shielded cable only. Type B Pull Boxes should be used for all other traffic signal cable applications. To eliminate multiple types of pull box quantities, Type B Pull Boxes can be used in lieu of Type A Pull Boxes. Pull boxes for fiber optic cable should be larger than standard pull boxes due to the large bending requirements of fiber optic cable (See TDOT Fiber Optic Standard Drawings).

7.1.2 Spacing of Pull Boxes

Pull boxes shall be located at 150-foot intervals for signal cable and detector cable runs. Pull boxes for interconnect cable runs shall be located at 300-foot intervals. Pull boxes for fiber optic cable runs shall be placed every 1,000 feet.

7.1.3 Pull Box Material

Pull boxes and covers are to be of load-bearing design in accordance with current TDOT standards and specifications.

7.2 Traffic Signal Conduits

All underground signal wiring shall be encased in conduit to protect the cables or conductors and facilitate maintenance. All signal wiring above ground shall be installed in conduit (e.g. risers), unless the wiring is inside of a pole or attached to a span wire or a messenger cable. Traffic signal conduits shall be in accordance with current TDOT standards and specifications (See TDOT *Standard Drawing T-SG-2*), the NEC and the NESC. Conduit used for traffic signal installation shall have the following characteristics:

7.2.1 Conduit Material Type

- **Underground:** In general, typical conduit placed below ground should be PVC Schedule 40 conduit except for the following locations:
 - **Under Roadways and Public Driveways:** When conduit is shown on the plans in areas which are subjected to heavier vehicular traffic, such as under roadways and public driveways, RGS or PVC Schedule 80 conduit shall be used;
 - **Under Private Driveways:** When conduit is shown on the plans in areas which are subjected to lighter vehicular traffic, such as under private driveways, PVC Schedule 80 conduit should be used. However, HDPE conduit can be substituted in lieu of the PVC Schedule 80 conduit.

PVC Schedule 40 and Schedule 80 conduit shall not be used together on the same conduit run (different inside diameter).

- **Risers:** All risers shall be RGS or PVC Schedule 80 conduit. When transitioning from overhead to underground or vice versa on a utility pole, a 2-inch diameter RGS riser must be specified for signal and interconnect cables.

7.2.2 Conduit Installation Methods

There are three typical construction techniques used to install underground conduits for traffic signals. The standard technique used by contractors is the open cutting (or trenching) method. When there are restrictions to using the open cut method, the conduit must be installed by either the directional bore method or the jacking method.

- **Open Cut Method:** The open cut method is generally permitted when the conduit is being installed in areas that will not affect traffic, such as grass medians, or within existing roadways when the existing pavement will be replaced upon project completion;

- **Directional Bore Method:** The directional bore method is generally used when the open cut method is not feasible. The directional bore method installs conduits by boring along a prescribed route under the roadway, driveway, or railroad track. The directional bore method requires an 8-foot by 8-foot staging area to install conduits less than six inches in diameter;
- **Jacking Method:** The jacking method pushes a pipe sleeve that is two inches larger in diameter than the conduit(s) that it will be conveying under a roadway, driveway, or railroad track. This method requires a jacking pit, which must be within the right-of-way. For 20-foot pipe sleeve sections, the jacking pit is typically 32-foot long and 6-foot wide. For 10-foot pipe sleeve sections, the jacking pit is typically 22-foot long and 6-foot wide.

7.2.3 Depth Installed Underground

Conduit is placed 18 inches to 50 inches below the finished grade, typically as follows:

- **Conduit Underground (Sidewalks, Medians, etc.):** Minimum of 18 inches between the top of the conduit and the finished grade;
- **Conduit under any Roadway Surface:** Minimum of 24 inches between the top of the conduit and the driving surface;
- **Conduit under Ditches:** Minimum of 24 inches of cover;
- **Conduit under Railroad Tracks:** Minimum of 50 inches between the top of the conduit and the top of the rails, or as required by the railroad company;
- **Communication/Interconnect Cables:** Minimum of 30 inches of cover between the top of the conduit and the finished grade.

7.2.4 Conduit Sizing

The maximum size conduit to be used on traffic signal installations shall be three inches. Where larger conduit capacity is required, multiple conduit runs will be used. The sizing of conduit(s) should be such as to not fill over 40% of the internal area of the conduit, as shown in Table 10.1. Typical traffic signal conduit shall be 2-inch diameter and detector loop conduit shall be 1-inch diameter, unless otherwise indicated. Conduits smaller than 1-inch diameter shall not be used. The only exception being that grounding conductors at service points shall be enclosed in 3/4-inch diameter conduit. No reducing couplings will be permitted. The conduit between a saw cut and a pull box for loop lead-ins shall be minimum 1-inch diameter. To determine the proper number and size of the conduits needed for the traffic signal layout, combine the number and wire size requirements for each conduit run using the cable/wire size requirements listed in Table 7.2.

Table 7.1 – Conduit Size Requirements

Conduit Inside Diameter (Inches)	Conduit Area	
	Area (Square Inches)	Maximum Usable Area, 40% of Total Area (Square Inches)
0.75	0.44	0.176
1.00	0.77	0.308
1.50	1.77	0.708
2.00	3.14	1.256
2.50	4.91	1.964
3.00	7.07	2.828

7.2.5 Communications Cable Conduit

All communications cables shall be run in a separate conduit from shielded cable, signal cable, and power cable. Conduit for communications interconnect cable should be 2-inch diameter.

7.2.6 Power Cable Conduit

Conduit for power supply shall be run in a separate, 1-inch diameter conduit.

7.2.7 Jacked and Bored Conduit

All jacked and bored conduit shall be RGS or HDPE. The estimation of the amount of boring is critical. Care should be taken for a realistic estimate.

7.2.8 Conduit Radii

All conduit bends shall be large radius to facilitate cable pulling (6" minimum radius).

7.2.9 Spare Conduit

Spare conduit stubs for future use shall always be installed in all new controller cabinet bases and pole foundations.

7.2.10 Conduit for Road Widening Projects

Conduit and pull boxes should be considered for installation on collector and arterial street widening projects where there is a potential for future interconnect needs.

7.3 Traffic Signal Wiring

All conductors shall be run inside conduit, except loop conductors in the pavement, cables run along messenger or span wire, or cables run inside poles. All new cable runs shall be continuous and free of splices. All signal cables shall be in accordance with current TDOT standards and specifications (See TDOT Standard Drawing T-SG-2), and shall meet the applicable requirements of IMSA, AWG, and NEC.

7.3.1 Signal Control Cable

All signal control cables shall conform to applicable IMSA Specification No. 19-1 or 20-1. Stranded cable color-coded AWG No. 14 shall be used for all signal and accessory circuits. All signal control cables shall be labeled in the cabinet.

7.3.2 Inductive Loop Wire

Conductors for traffic loops and home runs shall be continuous cross-linked polyethylene-insulated AWG No. 14 wire, conforming to IMSA Specification No. 51-1, 51-3, or 51-7, connected to the detector terminals or spliced with shielded detector cable within a pull box, conduit, or pole base (See TDOT Standard Drawing T-SG-3).

7.3.3 Loop Detector Lead-In Cable Wire

Loop detector lead-in cable wire shall be continuous AWG No. 14 wire conforming to the requirements of IMSA Specification No. 50-2, polyethylene-insulated, polyethylene-jacketed shielded cable (See TDOT Standard Drawing T-SG-2).

7.3.4 Preformed Loop Detector Wire

Preformed loop assemblies are suitable for placement under new asphalt or concrete pavement. Preformed loop detector wire shall consist of a minimum of four turns of No. 18 AWG wire or larger, not to exceed No. 14 AWG wire. The loop wires shall be installed in protective tubing with a diameter of less than 5/8 inch. The home run cable shall be installed inside conduit or the manufacturer's recommended enclosure between the pavement and the pull box to prevent damage in the ground (See TDOT Standard Drawing T-SG-3A).

7.3.5 Coordinated Systems Communications

The following are typical guidelines for coordinated systems communication:

- **Copper Communications Cable (Hard Wire):** Copper communications cable shall be 6-pair, AWG No. 19 polyethylene-insulated, polyethylene-jacketed cable with electrical shielding meeting the requirements of IMSA Specification No. 40-2;

- **Fiber Optic Communications Cable:** Fiber optic communications cable shall be specifically selected to meet the individual needs of a specific project. All fiber optic cables should be designed with spare fibers for future use. A rule of thumb is to double the fibers that are needed today and round up to the nearest six (fiber optic cable is manufactured in multiples of six);
- **Spread Spectrum Radio:** Communication using spread spectrum radio may be carried between units in master and local controller cabinets. Omni-directional antennas are used at master cabinet locations and uni-directional (Yagi) antennas are used at local cabinet locations.

7.3.6 Cable Lashing

Cables shall be attached to span or messenger cable by means of non-corrosive lashing rods or stainless steel wire lashings (one 360-degree spiral of lashing wire per foot).

7.3.7 Cable/Wire Sizing and Measurements

After the signal face and signal detector arrangements/placements have been determined, the necessary signal wiring required involves the following steps:

- **Signal Face Requirements:** The typical wiring requirement of each individual signal face may be determined by using TDOT Standard Drawing T-SG-12;
- **Mast Arm/Span Wire Runs:** Determine the length of wiring required for the signal faces depending on whether span wire or mast arms are used. In addition to horizontal distances shown on the construction plans, the designer must account for the height of the signal poles and five feet extra inside each pull box;
- **Detectors, Power and Interconnect Cable:** Determine the wiring required for detectors, power, and interconnect cables where applicable. In addition to horizontal distances shown on the construction plans, the designer must account for the height of the signal poles and five feet extra inside each pull box;
- **Cable/Wire Sizes:** The typical cable/wire sizes are shown in Table 7.2.

Table 7.2 – Typical Cable/Wire Sizes

AWG 10		
Number of Conductors	Outside Diameter (Inches)	Area (Square Inches)
1	-	-
2	0.511	0.205
3	0.542	0.231
4	0.623	0.305
5	0.695	0.379
6	-	-
7	0.756	0.449
8	-	-
9	N/A	N/A
10	N/A	N/A
11	-	-
12	0.946	0.703

AWG 12		
Number of Conductors	Outside Diameter (Inches)	Area (Square Inches)
1	-	-
2	0.466	0.171
3	0.492	0.190
4	0.552	0.239
5	0.590	0.273
6	-	-
7	0.677	0.360
8	-	-
9	0.834	0.546
10	0.854	0.573
11	-	-
12	0.881	0.610

AWG 14		
Number of Conductors	Outside Diameter (Inches)	Area (Square Inches)
1	-	-
2	0.399	0.125
3	0.421	0.139
4	0.458	0.165
5	0.500	0.196
6	-	-
7	0.543	0.232
8	-	-
9	0.707	0.393
10	0.721	0.408
11	-	-
12	0.731	0.420

AWG 16		
Number of Conductors	Outside Diameter (Inches)	Area (Square Inches)
1	-	-
2	0.358	0.101
3	0.382	0.115
4	0.419	0.138
5	0.460	0.166
6	-	-
7	0.499	0.196
8	-	-
9	0.572	0.257
10	0.606	0.288
11	-	-
12	0.669	0.352

Note: 1, 6, 8, and 11 conductor cables are not recommended for installation.

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