1 Traffic Signal Installation

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CHAPTER ONE: TRAFFIC SIGNAL INSTALLATION

In this chapter the construction of a traffic signal system is discussed. A technician working on a traffic signal is required to be aware that work activities progress very quickly, and any unresolved problems become the controlling operation for the completion of the work. For this reason, the technician should anticipate problems before they become the controlling operation. The following steps are recommended before any work is started by the Contractor:

1) Review Sections **805**, **806**, and **912.15** Section C of the current edition of the Manual of Uniform Traffic Control Devices, and the appropriate Standard Sheets.

2) Closely examine the plans, and field check the planned locations of all structures before the preconstruction conference. These include the controller, poles, pole anchors, detector housings, loops, handholes, and signal head locations.

3) Check the R/W distances as shown on the plans. This may usually be accomplished by reviewing old road plans held by the District Development Department.

4) After the locations of all underground utilities have been determined, again closely examine the structure locations and signal cable quantities for any conflicts. Any resulting changes outside the allowable limits of the Specifications or utility codes should be brought to the attention of the PE/PS, Area Engineer, or District Traffic Department.

5) In urban areas, check with property owners about possible basements extending out under the sidewalk areas.

WOODEN POLES WITH DOWN GUYS

Wooden poles with down guys are generally less expensive to install than steel strain poles and are not preferred by INDOT. When laying out and inspecting the locations where wooden poles and anchors are being installed, the following items are required to be considered:

1) Each wooden pole is required to be visually inspected, and meet the requirements of Section **913.15 (e) 2.**

2) The locations of the wooden poles are staked so they may be seen from any of the other pole locations.

3) Placing wooden poles or down guy anchors in the ditch line should be avoided.

4) Wooden poles are set a minimum of 7 ft in the ground and raked back out of plumb 12 in. The material excavated from the hole should be observed for possible utility conflicts.

5) For single spans, the pole anchors are located by extending the line of the span back 20 ft from the pole and swung a 7.5 ft arc in either direction.

6) For double spans, the pole anchors are located by extending the line which divides the extension of the two spans back 20 ft and swing a 7.5 ft arc in either direction.

7) Any pole anchor location change which would place the pole anchor closer than 15 ft from the wooden pole should generally not be permitted. The use of a strain pole should be investigated for cases of insufficient anchorage.

8) The line on the drilled hole for the pole anchor is required to be toward the top of the wooden pole.

9) The breaking of the expansion anchor and the proper backfill and compaction of the anchor assembly are critical to the proper functioning of the wooden pole. Initial and continued movement of the anchor assembly is required to be monitored.

STEEL STRAIN POLES

Steel strain poles (Figure 1-1) are used primarily on urban intersections. These poles have a much higher initial installation cost; however, the

service life is much longer than a wooden pole with down guys. When laying out and inspecting the locations where steel strain poles are being installed, the following items are required to be considered:

1) The Basis For Approval for the #4 and #10 bars in the foundation is the sequence number from a laboratory report unless they are from an approved list. The Basis For Approval for the concrete is the sequence number reported on the IT 652. The Basis For Approval for the steel strain pole and the anchor bolts is a Type C Certification.

2) The footing dimensions are 3 ft in diameter and 12 ft deep.

3) If bed rock, loose stones, or boulders more than 1/2 yd^3 in volume are encountered before the 12 ft depth is obtained, the PE/PS or Area Engineer should be contacted. Section **206.02(b)** Class X Excavation covers the procedure to be used if this occurs.

4) The Contractor always has the option of using a foundation casing if unstable soil conditions are anticipated.

5) The exposed portion of the foundation may be 3 ft in diameter or 3 ft square.

6) Adjacent anchor bolts are required to be oriented in the same direction with the span or spans attached to the steel strain pole.

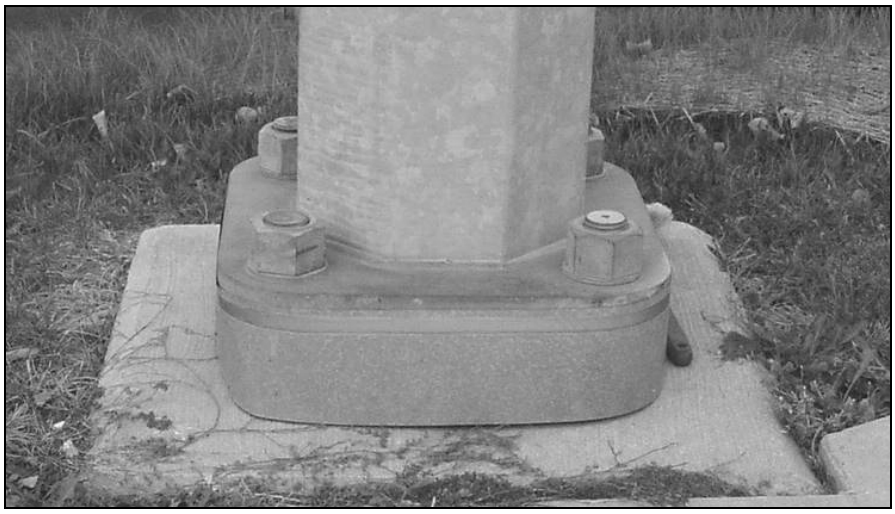

Figure 1-1. Steel Strain Pole

7) A tremie is used until the concrete is within 5 ft of the top of the foundation.

8) The steel strain pole foundation is finished 4 to 6 in. above the original ground and the top edge is chamfered. In locations where the foundation is located within the sidewalk, the sidewalk elevation is the top of the foundation.

9) Each foundation has a minimum of three conduit entries with grounding bushings.

10) Each steel strain pole is grounded by a continuous #6 bare copper wire from the grounding lug on the inside of the steel strain pole through the conduit grounding bushings and grounding duct to an 8 ft x 1/2 in. ground rod located 1 ft away from the foundation and 1 ft below the finished ground surface.

11) The exposed concrete surface of the foundation is rubbed after the forms are removed.

12) The steel strain pole is required to be raked back 12 in. away from each span.

13) If electrical service is on the steel strain pole, all three conduits from the steel strain pole are run to the controller**.** District Traffic should be consulted for possible future designs.

14) If a handhole is located within approximately 10 ft of a steel strain pole foundation on a corner other than the controller corner, one of the spare conduits is required to be run to that handhole for future use.

SPAN, CATENARY, AND DOWN GUYS

The span and catenary (Figure 1-2) are one of the first things that a motorist notices about a signalized intersection. If the span and catenary are sagging or look sloppy, the whole job looks bad.

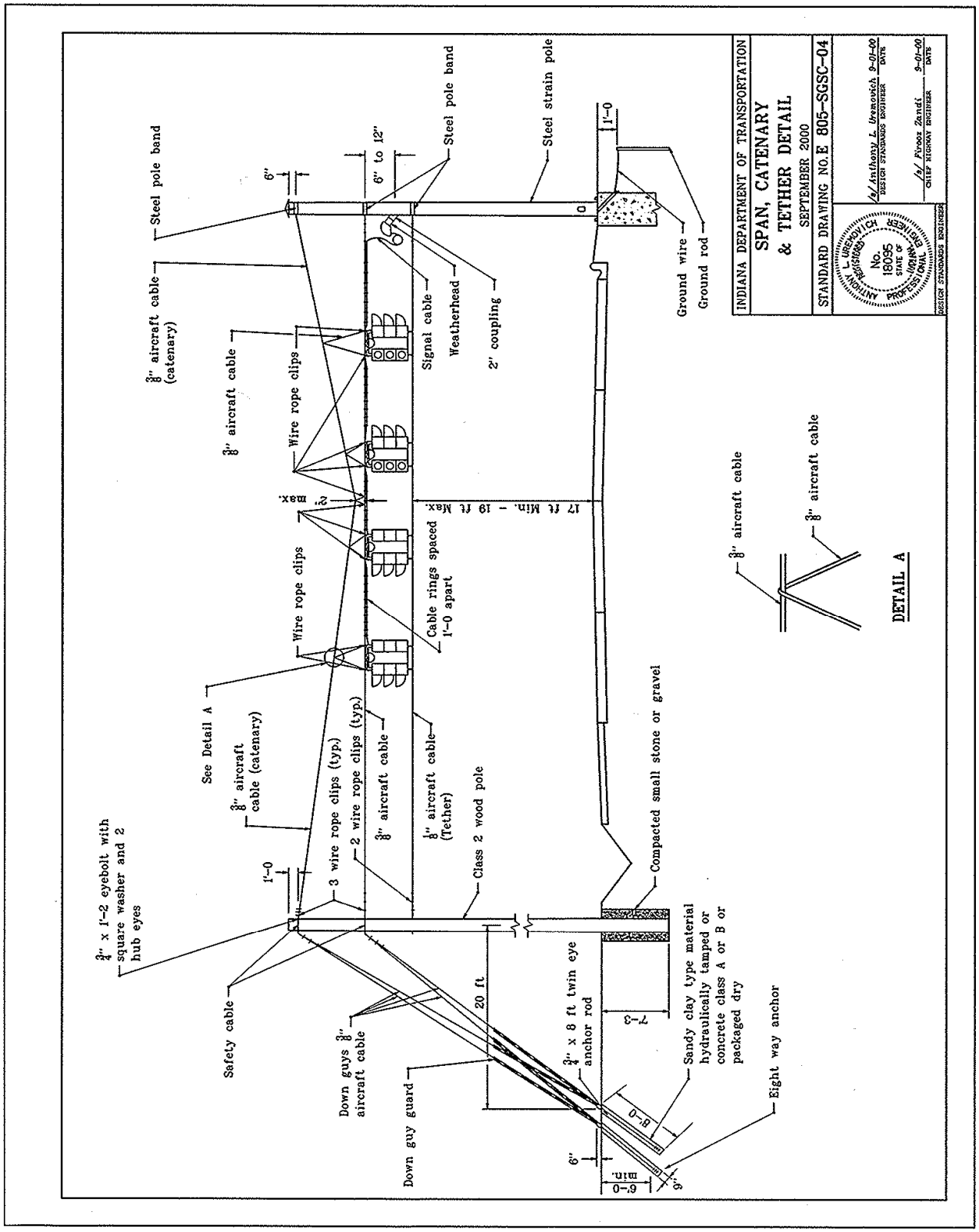

Figure 1-2. Span, Catenary, and Tether

When inspecting the installation of spans, catenaries, and down guys, the following items are required to be considered.

1) The Basis For Approval for 3/8 in. or 1/4 in. stainless steel aircraft cable is a Type C Certification.

2) Spans, catenaries, and down guys are 3/8 in. stainless steel aircraft cable, and "A" wires may be 1/4 in. wire rope or 3/8 in. aircraft cable. Tether lines are generally 1/8 in. aircraft cable.

3) Spans are required to be level. Therefore, a leveling mark should be placed on the side of each pole representing the pavement elevation at the lowest signal head.

4) The mounting height should be assumed to be 18 ft to the bottom of the lowest signal head, and 4 ft from the span to the bottom of a three section signal head or 5 ft from the span to the bottom of a four or five section signal head.

5) The span is located by measuring 22 or 23 ft from the leveling mark for the location of the drilled hole for the wooded pole or pole band for the steel strain pole.

6) The catenary is located a minimum of 12 in. below the top of either a wooden pole of steel strain pole. The catenary connection may have to be lower depending on overhead utility conflicts.

7) Three Crosby clamps are used at each eye bolt or pole band connection and are installed in alternate directions. Three bolt clamps are never used on aircraft cable.

8) The aircraft cable is doubled back 54 in. at each eye bolt or pole band connection. The first Crosby clamp is installed 3 in. from the eye bolt, the second 18 in. from the first, and the third 18 in. from the second.

9) Downguys are required to be in place before any work is conducted on the spans and catenaries of wooden poles.

10) The downguys is tightened until the top of the wooden pole starts to move.

11) A span jack is used to tighten the spans. For double spans, each span is jacked alternately until very tight.

12) The catenary swinging free is required to be between 18 and 24 in. above the span at the closest point.

13) The span and catenary are connected at the center of the span. The signal heads are supported and leveled from the catenary by means of "A" wires. Each "A" wire is connected at the bottom by two Crosby clamps spaced 12 to 24 in. apart. No Crosby clamp is used at the top of the "A" wire. The ends of the A wires are protected by servi-clips. "A" wires may be either 1/4 in. or 3/8 in. aircraft cable.

14) The National Electrical Code requires 8 ft vertical and 6 ft horizontal clearance from any overhead primary conductor.

SIGNAL HEAD INSTALLATION AND CLEARANCES

The traffic signal heads are in most cases the only part of the whole traffic signal system that the motorist actually sees. Therefore, the vertical and horizontal positioning and the directional orientation are critical to a well functioning system. When inspecting the installation of traffic signal heads, the following items are required to considered:

1) The Basis For Approval for signal heads and accessories is a Type C Certification.

2) Inspect each signal head assembly while still on the ground for the following:

   a. Physical defects

   b. Visor type

   c. Bulb sizes

   d. Lens orientation

   e. Wiring specifications

   f. Too much play between the balance adjustor and weatherhead clevis

   g. Approximate vertical hanging for each signal head

3) Signal head clearances are required to be between 17 ft and 19 ft

4) Signal heads are adjusted vertically to approximate a uniform grade of all like signal heads.

5) Signal heads are located and aimed according to the plans. The minimum spacing between signal heads serving the same direction is 8 ft The minimum spacing between free swinging signal heads not serving the same direction is 4 ft The District Traffic Department should approve the layout of signal heads.

6) If a tether line is specified (Figure 1-3), all the signals are required to be aligned vertically. This may have to be done several times if the span or catenary requires adjustment. The tether line is designed to break if hit.

Figure 1-3. Tether Line

7) If a signal head is required to be mounted more than 2 h before use, then the entire signal head is hooded.

8) Hooded signal heads are not to be left up for more than five days.

DISCONNECT HANGER INSTALLATION

The disconnect hanger (Figure 1-4) is an electrical junction box generally suspended at a specified location on the span, and all the wiring connections are conducted while on the span. When inspecting the installation of a disconnect hanger the technician is required to consider the following items:

1) The Basis For Approval for disconnect hangers is a Type C Certification.

2) Each disconnect hanger is inspected on the ground for physical defects, tightness of door latch and span hanging connections, and an 18 circuit terminal block.

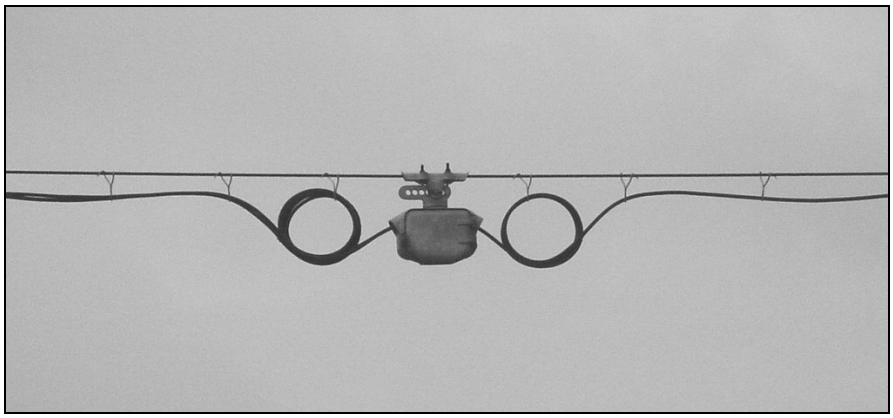

Figure 1-4. Disconnect Hanger

TRAFFIC SIGNAL CABLE INSTALLATION

Traffic signal cable is the multi-conductor cables which carry electrical impulses from the power source to the entrance switch, from the entrance switch to the controller, from the controller to the signal heads, and from the controller to the detection devices. Pay items are designated by the number of conductors in the cable and the gauge of the cable. When inspecting the installation of traffic signal cable, the technician is required to consider the following items:

1) The Basis For Approval for all traffic signal cable is a Type C Certification.

2) The color coding scheme is required to be discussed at the preconstruction conference and should conform to the District policy.

3) Fused and unfused cables are not permitted to occupy the same conduit. 3C/8 (3 conductor 8 gage wire) traffic signal cable is considered unfused.

4) The only acceptable underground splice in a handhole is a poured epoxy splice.

5) In above ground pole handholes, an acceptable splice is a "standing splice" utilizing wire nuts and electrical tape wrapping.

6) For traffic signal cable hung from a span, cable rings are spaced at 12 in.

7) Traffic signal cable quantities are required to be verified. However, plan quantity is paid if the measured quantity is within ± 25% of planned quantity.

DRIP LOOP INSTALLATION

The purpose of a drip loop (Figure 1-5) is to prevent water from entering the weatherhead at either a signal head, disconnect hanger, or traffic pole. Drip loops are required to be approximately 6 in. in diameter, contain at least one full turn of traffic signal cable, and be wrapped tightly with several wraps of electrical tape. The drip loop should not rub against the traffic signal head.

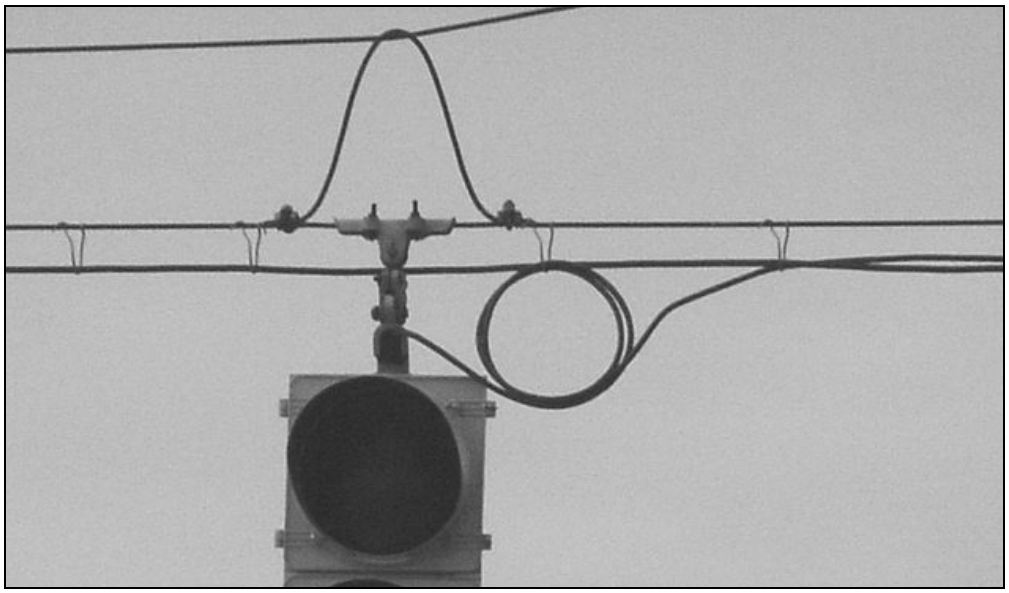

Figure 1-5. Drip Loop

POLE AND MAST ARM INSTALLATION

Pole and mast arm installations (Figure 1-6) are found in urban areas where spans and catenaries are either impractical or not as esthetically pleasing as poles and mast arms.

Figure 1-6. Pole and Mast Arm

When inspecting the installation of a pole and mast arm system, the following items are required to be considered:

1) The Basis For Approval for the pole, mast arm, anchor bolts, and accessories is a Type C Certification. The Basis For Approval for the concrete used in the footing is the sequence number reported on the IT 652.

2) Field check each footing location using the planned mast arm length and locate the end span signal head according to the plans. Any apparent errors in the plans are required to be

Reported to the PE/PS immediately.

3) Check the R/W distances as shown on the plans to be sure that the footing is entirely within the R/W.

4) After the underground utilities have been located, check to insure that the footing locations meet the following criteria:

   a. The face of the pole is required to be at least 18 in. from the face of the curb.

   b. Underground utility clearance requirements are required to be satisfied. Encasement of an underground utility should never be considered without prior consent of the utility company. Unexpected or mismarked underground utilities are one of the largest causes of contract delay.

   c. Do not locate a footing within the confines of a wheel chair ramp or where a wheel chair would have difficulty maneuvering. If the foundation is required to be in the curb ramp area, then move the foundation as far out of the ramp as possible and place the top of the foundation level with the curb ramp grade. If Walk-Don't Walk indications are specified, they are required to be clearly visible from the beginning of the crosswalk to within 10 ft of the opposite side. The footing should be kept as close to the crosswalk lines as possible.

   d. The footings are located so that the signal heads are between 40 and 120 ft from the stop bar.

   e. The location of the footing may be moved a maximum of 2 ft perpendicular to flow of traffic, but the mid-mast signal head should still be located at a lane width spacing from the end mast arm signal head. The mid-mast signal head is never located beyond the curb line and the minimum spacing between signal heads is 8 ft.

5) If possible, locate the footing entirely off the sidewalk.

6) Each footing has a minimum of three conduit entries.

7) Each mast arm pole is grounded by a continuous #6 bare copper wire from the grounding lug on the inside of the mast

arm pole through the conduit grounding bushings and grounding duct to an 8 ft x 1/2 in. ground rod located 1 ft away from the foundation and 1 ft below the finished surface.

8) If the footing is greater than 5 ft deep, a tremie is required below the 5 ft level.

9) If the footing is located in a sidewalk area, the footing is finished flush with the surrounding sidewalk. If the footing is located in a non-sidewalk area, the footing is finished 4 in. above the original ground using chamfered edges around the top of the footing.

10) Expansion joint material is used when the footing comes in contact with any other concrete.

11) The Walk-Don't Walk indications are located on the pole in such a manner as to provide protection from truck turning movements.

12) The bottom of the mid-mast mounted signal head is adjusted level with the end of the mast arm signal head.

ELECTRICAL SERVICE AND ENTRANCE SWITCH INSTALLATION

The electric service (Figure 1-7) requirements vary with the utility company involved. Generally speaking, if the electric service does not meet any of the requirements of that utility company, the electricity is not hooked up.

Figure 1-7. Electrical Service and Entrance Switch

When inspecting the installation of an electric service the following items are required to be considered:

1) The Basis For Approval for the entrance switch, the conduit riser, the weatherhead, the traffic signal cable and all other miscellaneous material is a Type C Certification.

2) 3C/8 stranded traffic signal cable is used for the electrical service from the service weatherhead to the entrance switch, and from the entrance switch to the controller.

3) At least 4 ft of 3C/8 is left rolled up at the weatherhead.

4) An electric meter is placed above the entrance switch if required by the local power company, or if specified by INDOT.

5) Since the controller operates on 120 volts, one conductor of the 3C/8 is terminated at the entrance switch.

6) For an electric service on a steel strain pole, a 1 in. riser with weatherhead is placed on the outside of the steel strain pole. Conduit hangers are banded to the outside of the steel strain pole and the conduit is installed on the hangers.

7) An oxidation inhibitor is applied to all surfaces that mate with a dissimilar material, such as aluminum to steel.

8) Conduit straps or hangers are placed 1 ft from the weatherhead and at a maximum spacing of 5 ft from there down.

9) Entrance switch enclosures are required to contain a single pole 50 amp breaker.

10) The bottom of the entrance switch is mounted at a height of 4 ft.

11) The entrance switch is grounded by means of a #6 bare solid copper wire encased in a 1/2 in. electrical conduit between the entrance switch and the ground rod.

12) The 8 ft x 1/2 in. ground rod is located 1 ft outside the pole or foundation and 1 ft below the ground surface. The grounding connection is required to be an approved type.

CONTROLLER INSTALLATION INCLUDING FOUNDATION

The traffic signal controller (Figure 1-8) is the mechanism which makes the traffic signal system operate the way intended. The technician should never change any of the settings of any of the equipment inside the controller cabinet. Only a trained District Traffic Signal Technician has the authority to set or change any of the various controller timings.

Figure 1-8. Traffic Signal Controller

When inspecting the installation of a traffic signal controller, the following items are required to be considered:

1) The Basis For Approval for the concrete used in the foundation is the sequence number from the IT 652. The Basis For Approval for the controller, cabinet, and all accessory items is a Type C Certification, and an approval number from a list of approved materials issued by the Office of Materials Management.

2) The controller cabinet is in the same direction oriented so that a traffic signal technician standing at the controller with the door open may see the majority of the signal heads.

3) Always try to anticipate any future maintenance problems you might be creating.

4) Check the plans and standard sheets for the controller foundation location, type, dimensions, and anchor bolt placement.

5) There will be a minimum of three conduit entries into the controller foundation. There should always be a spare conduit entry. The price of a few extra feet of conduit is small compared to the price of relocating the controller foundation on a future modernization contract.

6) The top edges of the controller foundation are required to have chamfered edges, and the exposed sides of the foundation be rubbed.

7) Controller "A" bases in non-sidewalk areas are finished 4 in. above the finished ground level and the top edges are chamfered. Controller "A" bases placed in sidewalk areas are finished flush with the surrounding sidewalk.

8) The top of the controller foundation is required to be sloped toward the controller drain.

9) A continuous run of #6 bare copper wire connects the grounding lug on the controller back panel, each conduit grounding lug, and the approved grounding connection to the ground rod.

10) An 8 ft x 1/2 in. ground rod is placed 1 ft outside the confines of the controller foundation, and 1 ft below the finished ground level.

11) The controller cabinet door is required to open and close easily when the controller cabinet is properly aligned on the controller foundation. The outside lower edges of the controller are sealed all around with a silicone sealer.

12) All field wiring (Figure 1-9) is required to be neat and easy to follow. The "bird nest" affect is discouraged.

Figure 1-9. Controller Cabinet Wiring

13) All traffic signal cables entering the controller cabinet, signal poles, and handholes are tagged with aluminum tags indicating the signal phase, pedestrian phase, power, pedestrian actuation, or loop phase.

14) On traffic signal modernization contracts, the old and the new systems are kept independent of each other at all times.

15) A District Traffic Technician is required to always be present when a new signal system is turned on for the first time.

16) Newspapers, TV and radio stations, schools, and law enforcement agencies are notified of the new signal turn on dates.

17) A new traffic signal system at an intersection where a traffic signal system did not exist beforehand or where a flashing beacon system is being upgraded to a traffic signal system are required to remain on flash for at least three days prior to placement on normal operation. A new signal is never placed on normal operation on a Friday or just before a holiday.

A partially completed IC 636A is required to be sent to the District Traffic Office indicating the signal turn-on date and time.

STEEL CONDUIT INSTALLATION

Steel conduit is used to carry the traffic signal cable between the controller and all points of intended use. When inspecting the installation of conduit, the following items are required to be considered:

1) The Basis For Approval for conduit is a Type C Certification.

2) Steel conduit is required to be 2 in. nominal diameter.

3) Rigid grade and intermediate grade steel conduit are both acceptable. Most Contractors elect to use rigid conduit.

4) PVC conduit is also acceptable, but the 12 in. cover of B-borrow is financially unattractive to most Contractors. PVC conduit also requires 2 in. of B borrow under the conduit.

5) Steel conduit is installed to a depth of no less than 24 in. below the finished grade, unless otherwise indicated.

6) The maximum length for a straight run of conduit between handholes is approximately 250 ft This figure may be considerably less depending on the number of bends in the run of conduit.

7) All conduit inside a foundation is included in the price of the foundation.

8) Pushed or jacked conduit is the most expensive conduit for the Contractor. Pushing or jacking methods are required to not create an excessive void around the conduit, and the jacking pit is kept a minimum of 2 ft from the nearest pavement or shoulder.

9) The edges of all street cuts for detector housings or stopped jacked conduits are required to be sawed.

10) Compacted B borrow is used for the backfill of all street cuts not at a detector housing.

11) Except at detector housings, street patches are required to match the surrounding pavement. 12 in. of concrete and 1 to 2 in. of HMA surface mix are acceptable patches for HMA pavement.

HANDHOLE INSTALLATION

Handholes (Figure 1-10) are junction points for conduit and pulling points for the traffic signal cables in these conduits. Handholes are placed as near as possible to the locations as shown on the plans.

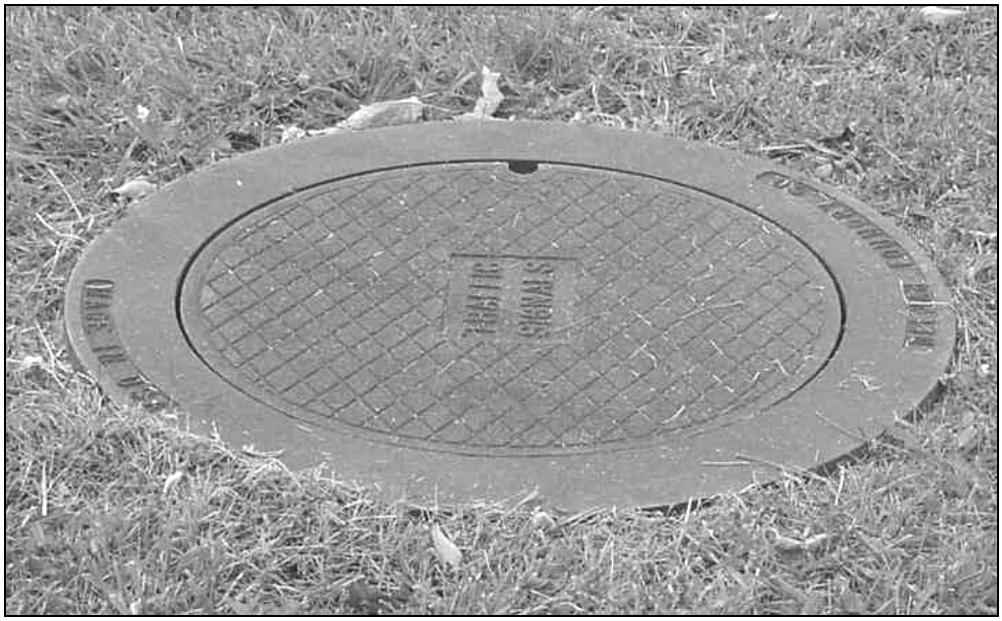

Figure 1-10. Handhole

When inspecting the installation of handholes, the following items are required to be considered:

1) The Basis For Approval of the handhole tile is an approval number (P number) stenciled on the side of the tile. The Basis For Approval of the handhole ring and cover is a Type C Certification.

2) Handholes are required to be class III reinforced concrete pipe and be constructed per Standard **805 SGCF-04**. Handhole tiles with pre-poured concrete bases are not approved for INDOT use.

3) Handholes are placed in the direct line of the conduit run, if possible.

4) 250 ft is the maximum handhole spacing for a straight run of conduit.

5) A handhole is not placed in a ditch line.

6) A handhole is located to alleviate any possible water standing in a conduit and to prevent any water from backing up into the controller cabinet.

7) The grade of the ring and cover are required to match the existing grade.

8) 12 in. of pea sized or larger gravel is used under the bottom of the handhole unless the parent material is granular.

9) Concrete for the 5 in. pad is worked under the handhole tile. Concrete for the 5 in. pad may be either class A, B, C, or bag mix conforming to **ASTM C 387**.

10) Conduits are required to extend 3 to 6 in. beyond the inside wall of the handhole tile and be grouted. Grout mix is required to conform to **ASTM C 387**.

11) All conduits are required to have bushings.

12) All traffic signal cable are required to have approximately 2 ft of slack in a handhole.

DETECTOR HOUSING AND TRAFFIC DETECTION LOOP INSTALLATION

Properly installed detector housings (Figure 1-11) and traffic detection loops are critical to the intended functioning and the expected service life of the detection system. The technician is required to know what to look for to avoid potential failures in the detection system in the future.

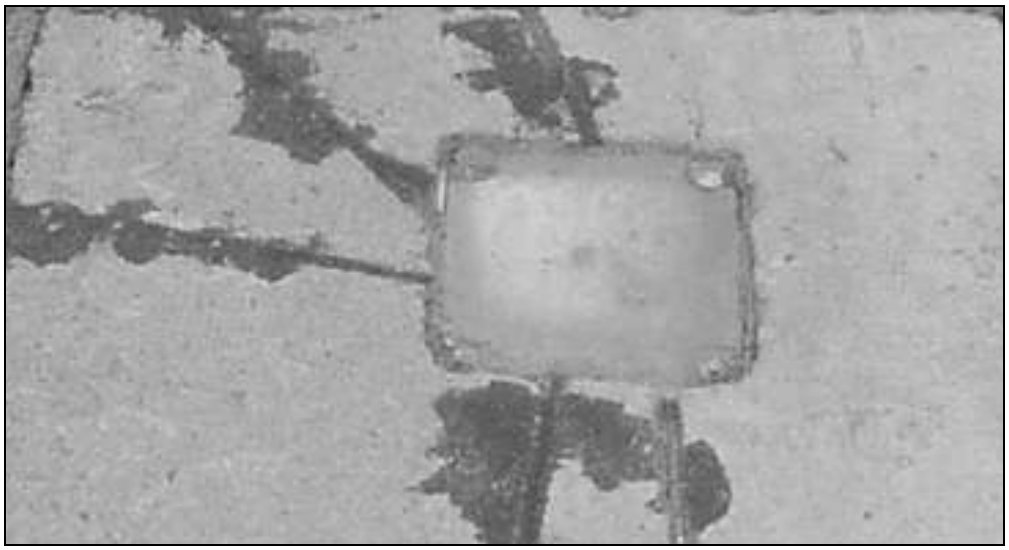

Figure 1-11. Detector Housing

When inspecting the installation of detector housings and traffic detection loops, the following items are required to be considered:

DETECTION HOUSING INSTALLATION

1) The Basis For Approval for the concrete used in the detector housings is the sequence number from the IT 652. The Basis For Approval for the aluminum detector housing, the 1C/14 loop wire, and loop sealant is a Type C Certification.

2) The detector housings, traffic detection loop corners, and the stop bars are first laid out according to the plans.

3) If possible, avoid crossing a working joint or working crack with a loop wire. Moving the location of a detector housing or traffic detection loop 2 or 3 ft to avoid crossing a working joint or crack is acceptable. A detector housing may be butted up against a contraction joint.

4) If the side of a loop runs parallel to a joint or crack, at least 1 ft of clearance is required to be maintained between the loop and the joint or crack.

5) Observe traffic flow for drivers' habits, incidents of false calls, drivers overrunning the loops, or stopping too soon to be detected by the loops. If a major change in the location or number of loops is required, contact the Area Engineer or District Traffic Office before making such a change.

6) Detector housings are generally placed inside the pavement, but should not be located where water is likely to stand, such as in a gutter line.

7) Galvanized steel elbows are used in the detector housings.

8) Detector housings poured in pavement under traffic are poured using high early strength concrete. The high early strength concrete may be made with 564 pounds per cubic yard of type III or type IIIA portland cement or with 846 pounds per cubic yard type I or type IA portland cement.

9) The freshly poured detector housing is covered with a steel plate, generally at least 3 ft x 3 ft, for the cure time of the concrete (Section **702**).

10) HMA cold mix around the edges of the plate works well to hold the plate in place.

11) Where a portion of the road is closed or where there is no vehicular traffic, class A concrete may be used to pour detector housings.

12) Work is required to be scheduled so that a detector housing is poured the same day that the area is dug.

The aluminum detector housing and surrounding concrete base are required to be finished flush with the surrounding pavement; however, the aluminum detector housing may be finished 1/2 in. below the surrounding pavement.

SAWING LOOPS (Figure 1-12)

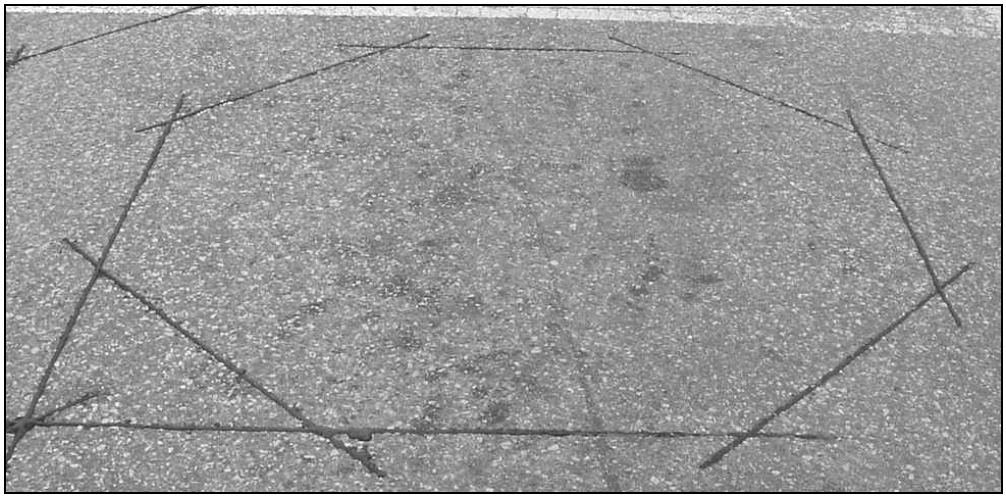

Figure 1-12. Saw Loops

1) The Contractor has the option to use either wet or dry saw blades on the saw slots. However, wet blades are discouraged in freezing weather, and dry blades are discouraged in urban areas where air pollution standards may be violated.

2) The width of a saw slot is required to be between 3/8 in. and 7/16 in.. The minimum saw slot depth in concrete is required to be 3 in. (2 in. + 1 in. of cable), and in HMA the slot depth is 3½ in. (2½ in. + 1 in. of cable).

3) All loops are required to be octagonal (eight sided) in shape with sides of 2 ft 6 in. in length.

4) All loop locations are subject to the approval of the District Traffic Engineer, who is notified at least 48 hours prior to any loop placement.

5) No more than one loop may be served by the same saw cut.

6) Always saw deeper and wider when crossing a working joint or crack, and leave slack in each turn of the loop wire.

7) The saw slots are inspected for their total length for depth requirements. The saw slots are required to be totally dry before the loop wire is placed.

INSTALLATION OF LOOP WIRE

1) All loops are required to be wired with 4 turns unless otherwise noted.

2) THW 1C/14 (one conductor 14 gage wire) wire inside a 1/4 in. O.D. PVC jacket is specified for loop wire.

3) All loop wire is placed in the saw slots in a clockwise manner as viewed from above.

4) Loop wires are pressed into the saw slots with a blunt non-metallic object.

5) A 1/2 in. diameter x 2 in. backer rod spaced at 15 in. intervals is installed over the loop wire. This prevents the loop wire from floating up while the sealant is applied. The loop wire is placed on the bottom of the saw slot.

6) At no time is the loop wire bent at angles less than 120 degrees.

7) All loops are is wired in series (the end tagged "in" of one loop attached to the end tagged "out" of the next loop) unless otherwise noted.

8) The loop lead-in wires (between the loop and the detector housing) is twisted around each other a minimum of 5 turns/ft, tied with cable ties, and coiled in the detector housing.

9) A maximum of 18 in. and a minimum of 12 in. of loop wire is allowed in the detector housing for each loop lead-in wire.

10) In the detector housing, each lead-in wire is tagged as either "in" or "out".

11) The black wire from the 2/16 shielded cable is spliced to the free loop lead-in wire tagged "out", and the white wire from the 2/16 shielded cable is spliced to the free loop lead-in wire tagged "in".

12) The Contractor is required to meter each loop at the detector housing and each 2C/16 shielded cable at the controller. The technician witnesses and records each of the following test procedures:

    a. Inductance in micro-henries performed at the detector housing and at the controller cabinet.

    b. Resistance in ohms performed at the detector housing and at the controller cabinet.

    c. Induced A.C. voltage in volts performed at the detector housing and at the controller cabinet.

    d. Leakage resistance in mega-ohms performed at the controller cabinet after the splices in the detector housing have been fully submerged for two minutes in a solution containing water and one table-spoon of baking soda.

13) Values for the above tests are required to meet the following before the loop installation is accepted:

    a. 80 - 800 micro-henries

    b. Less than or equal to 8 ohms

    c. Less than or equal to 3 volts

    d. Greater than 100 mega-ohms

14) All loop testing is conducted at the detector housing before the loop wires are spliced and at the controller cabinet after the loop wires have been spliced. No loop sealant is placed until all the loop tests have been successfully completed. The loop sealant is not placed until all the loop tests have been successfully completed.

15) The vehicle simulator test is also required before the loops are accepted. The test vehicle is fabricated with an 8 ft long piece of #6 bare copper wire formed into a circle. The two ends are twisted together and the circle is drug across the loop by a non-conductive string. The loop amplifier records a call as the circle is pulled across the loop and the call should be cancelled as the circle leaves the loop.

16) The loop sealant is required to be from a list of approved loop sealants issued by the Office of Materials Management.

17) All loop splices are soldered and waterproofed in accordance with Standard Sheets.

THERMOPLASTIC, PREFORMED PLASTIC, AND EPOXY PAVEMENT MARKING INSTALLATION

The locations of stop bars and cross walk lines may be dependent upon the locations of the signal heads, walk-don't walk indications, wheelchair ramps, and the traffic detection devices. When installing thermoplastic or preformed plastic pavement markings, the following items are required to be considered:

1) The Basis For Approval for thermoplastic and preformed plastic pavement markings is a Type C Certification. The Basis For Approval for 100% solids epoxy is a Type A Certification. The Basis For Approval for the glass spheres depends upon the quantity used as set out in the current edition of the Frequency Manual.

2) Check with your PE/PS or the Specifications for the weather limitations of each material used.

3) The following design considerations are important in laying out stop bars and cross walks:

   a. Common sense and observation of all traffic movements is used in the determination of stop bar and cross walk locations. The stop sign location is usually not the best place to layout the stop bar due to the site distance. Check with your PE/PS, Area Engineer, or District Traffic for the best location.

   b. The beginning of the stop bar is required to be at least 40 ft from the nearest signal head and not more than

120 ft from the farthest signal head serving that direction.

c. There is required to be a minimum of 4 ft clearance between the stop bar and the nearest point on the cross walk line.

d. The cross walk lines run parallel and are separated by a minimum of 6 ft.

e. Cross walk lines are required to proceed in a straight line from wheel chair ramp to wheel chair ramp.

f. Try to avoid crossing manhole covers or straddling any transverse joint or crack.

4) The following removal of existing pavement markings is included in the unit price for new pavement markings:

a. All incorrect and clearly visible existing stop bars and cross walk lines on HMA pavement.

b. All existing preformed plastic pavement markings on HMA pavement. These are generally brittle and easily dislodged at the curb line, and show sign of deformation in the wheel tracks.

c. All visible pavement markings on concrete pavement.

5) Thermoplastic may be placed over existing well worn thermoplastic or well worn traffic paint.

6) The pavement surface is required to be dry and at least 55°F for thermoplastic and 60°F for preformed plastic pavement markings.

7) The application area is pre-stripped on all types of pavement with a manufacturer approved binder material to insure adhesion.

8) Thermoplastic application temperatures are required to be between 400 and 450°F.