



INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 11-23 **Technical Advisory**

October 31, 2011

TO: All Design, Operations, and District Personnel, and Consultants

FROM: /s/ Alfredo B. Hanza
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Highway Design and Technical Support Division

SUBJECT: Traffic-Signal Cantilever Structure

REVISES: *Indiana Design Manual Section 77-4.03*

ADDS: *Indiana Design Manual Section 77-4.04*

SUPERSEDES: Design Memorandum 11-20 Technical Advisory

EFFECTIVE: January 11, 2012, Letting

A signal-cantilever structure is designed to satisfy the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 2009, Fifth Edition.

A signal-cantilever structure and its foundations should be as shown on Recurring Plan Detail 805-T-177d. See section I below for guidance in selecting a standardized structure for use. See section II below for design criteria for a non-standardized structure.

I. Selection Guidance

Recurring Plan Detail 805-T-177d shows details for standardized signal-cantilever structures, pole section 2, combination arm, and drilled-shaft and spread foundations.

If soil-borings information is available for a roadwork project that the signalized intersection is part of, it should be used to determine if soil is cohesive or sand, the soil-bearing capacity, and the friction coefficient. Otherwise, the designer should contact the Office of Geotechnical Services. If soil-properties information is unavailable, one boring should be made at the intersection to be signalized. Once the soil properties are known, and the values are equal to or higher than those shown in Figure 11-23A, the foundation type can be determined as shown in the Figure.

Founda-tion Type	Soil Properties	Support	Arm Length, L , ft
A	Cohesive, $Q_u = 750$ lb/ft; or Sand, Friction Angle = 30 deg.	Drilled Shaft	≤ 35
B	Allow. Bearing Capacity = 1200 psf, and Coeff. of Friction = 0.3	Drilled Shaft	$35 < L \leq 60$
C	Cohesive, $Q_u = 750$ lb/ft; or Sand, Friction Angle = 30 deg	Spread Footing	≤ 35
D	Allow. Bearing Capacity = 1200 psf, and Coeff. of Friction = 0.3	Spread Footing	$35 < L \leq 60$

**SIGNAL-CANTILEVER-STRUCTURE
FOUNDATION-TYPE DETERMINATION**

Figure 11-23A

If the soil properties are such that the values are lower than those shown in Figure 11-23A, the foundation should be designed, and its details should be shown on the plans.

A signal-cantilever structure should be designed to provide a minimum clearance of 17.5 ft under each signal head or sign. Clearance should be the vertical distance from the lowest point of the signal head or sign to a horizontal plane to the pavement surface below the signal head or sign.

A three-section signal head may be placed where a five-section signal head is shown on Recurring Plan Detail 805-T-177d.

The structure should be provided with vibration-mitigation devices if either of the conditions applies as follows:

1. structure with arm length in excess of 50 ft; or
2. structure is located where the speed limit exceeds 35 mph and the ADT exceeds 10,000, or the ADTT exceeds 1000. ADT and ADTT are for one direction regardless of the number of lanes.

The foundation location and type, pole height, arm length, and sign designations and messages should be shown on the plans. The true arm length should be shown from the center of the pole to the end of the arm. Such length, for pay-item-determination purposes, should be rounded to the higher 5-ft increment. The plans should show ADT and ADTT for each direction.

II. Design Criteria

If a structure shown on Recurring Plan Detail 805-T-177d cannot be used, its foundation, pole, arm, and connections should be designed utilizing the design conditions as follows:

1. wind speed of 90mph;
2. service life of 50 yr;
3. fatigue Category II;
4. galloping considered;
5. truck gusts considered with truck speed of 60 mph;
6. backplates included for signal heads; and
7. C_d for structure members = 1.1 for fatigue and in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals*, Table 3-6 for working loads.

A signal cantilever structure should be designed for weights equal to or less than those shown in Figure 11-23B.

Device	Area, ft ²	Weight, lb
Signal Head with Backplate, 3 Sec., Lens Dia. 12 in.	8.7	35
Signal Head with Backplate, 5 Sec., Lens Dia. 12 in.	13.1	55
Regulatory Sign, 36 in. x 30 in.	7.5	19
Street-Name Sign, 18 in. x 96 in.	12	30
Street-Name Sign, 18 in. x 132 in.	16.5	41
Mounted Camera	1	20
Top-Pole Luminaire	2.4	53

AREA AND WEIGHT OF DEVICE TO BE MOUNTED ON SIGNAL CANTILEVER

Figure 11-23B

If necessary, the combination arm can be added by including pole section 2, diameter of either 17 in. or 24 in., also designed for weights equal to or less than those shown in Figure 11-23B.

Where used, the combination-arm length should be equal to or less than the length of the signal-cantilever arm.

The pole's maximum allowable horizontal deflection should be limited to 2.5% of the structure height in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals*, Section 10.4.2, group 1 load combination.

III. Pay Items

The pay items for signal cantilever structure, mast arm, have been obsoleted.

The new code numbers and pay items are as follows:

805-11373	Signal Cantilever Structure, Signal Arm 15 ft
805-11374	Signal Cantilever Structure, Signal Arm 20 ft
805-11375	Signal Cantilever Structure, Signal Arm 25 ft
805-11376	Signal Cantilever Structure, Signal Arm 30 ft
805-11377	Signal Cantilever Structure, Signal Arm 35 ft
805-11378	Signal Cantilever Structure, Signal Arm 40 ft
805-11379	Signal Cantilever Structure, Signal Arm 45 ft
805-11380	Signal Cantilever Structure, Signal Arm 50 ft
805-11381	Signal Cantilever Structure, Signal Arm 55 ft
805-11382	Signal Cantilever Structure, Signal Arm 60 ft
805-11430	Signal Cantilever Structure, Pole Section 2, Pole Dia. 17 in.
805-11431	Signal Cantilever Structure, Pole Section 2, Pole Dia. 24 in.
805-11433	Signal Cantilever Structure, Combination Arm 15 ft
805-11434	Signal Cantilever Structure, Combination Arm 20 ft
805-11435	Signal Cantilever Structure, Combination Arm 25 ft
805-11436	Signal Cantilever Structure, Combination Arm 30 ft
805-11437	Signal Cantilever Structure, Combination Arm 35 ft
805-11438	Signal Cantilever Structure, Combination Arm 40 ft
805-11439	Signal Cantilever Structure, Combination Arm 45 ft
805-11440	Signal Cantilever Structure, Combination Arm 50 ft
805-11441	Signal Cantilever Structure, Combination Arm 55 ft
805-11442	Signal Cantilever Structure, Combination Arm 60 ft
805-11383	Signal Cantilever Structure, Drilled Shaft Foundation, A
805-11384	Signal Cantilever Structure, Drilled Shaft Foundation, B
805-11387	Signal Cantilever Structure, Spread Footing Foundation, C

805-11388 Signal Cantilever Structure, Spread Footing Foundation, D

The pay unit for all items is each.

IV. Recurring Plan Detail and Recurring Special Provisions

Recurring Plan Detail 805-T-177d should be called for, along with Recurring Special Provisions 805-T-169 and 922-T-168, if one or more of the pay items listed above is required. The recurring documents appear on the Department website, at <http://www.in.gov/dot/div/contracts/standards/rsp/sep11/sec800.htm>.

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805-T-169 TRAFFIC SIGNALS

(Revised 09-15-11)

The Standard Specifications are revised as follows:

SECTION 805, BEGIN LINE 1, DELETE AND INSERT AS FOLLOWS:

SECTION 805 – TRAFFIC SIGNALS

805.01 Description

This work shall consist of furnishing miscellaneous materials, not furnished by the Department, and installing traffic signals in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans or as directed.

MATERIALS

805.02 Materials

Materials shall be in accordance with the following:

Castings for Handhole.....	910.05(b)
Coarse Aggregate, Class E or Higher, Size No. 8.....	904
Concrete, Class A, B, or C	702
<i>Loop Detector Sealant.....</i>	<i>906.02(a)</i>
Reinforced Concrete Pipe	907.02
Traffic Signal Materials and Equipment.....	922
Treated Lumber.....	911.02

The proposed work shall be examined in order to determine what materials not furnished by the Department are required to complete the contract. The Department will furnish only the materials specified on the Department Furnished Materials special provision. If materials to be furnished by the Contractor are listed, the list is only a guide for estimating purposes. All additional materials required to complete an operating installation as specified shall be furnished.

Signal handholes shall be class III reinforced concrete pipe as shown on the plans.

Joint sealant material shall be compatible with the roadway materials. If polyethylene duct loop wire is used, only sealant in accordance with 906.02(a)1 shall be used.

Preformed pave-over loops shall be designed for use with HMA, SMA or PCCP as applicable.

Wood poles to be furnished shall be in accordance with the current ANSI specifications and dimensions. They shall be of the length and class specified, be fully treated in accordance with 922.05-10(b), and dry. Minimum circumference at the top and at a point 6 ft (1.8 m) from the butt shall be in accordance with ANSI specifications.

Steel strain poles greater than 24 ft (7.3 m) in length shall be in accordance with 922.0510(a).

The battery cabinet and program timing module for solar powered flashing beacons shall be from the Department's Approved List of Traffic Signal and ITS Control Equipment.

CONSTRUCTION REQUIREMENTS

805.03 General Requirements

The Contractor shall maintain existing traffic signals in operation until the Engineer determines that the progress of the work necessitates their removal. The new installation shall not interfere with the operation of the existing signal. The work shall proceed in such a manner that the signals are not out of service at any 2 adjacent intersections at any time. When the operation of an existing traffic signal must be interrupted before the new signal is placed in operation, the traffic shall be controlled at all times. The work shall be scheduled so that the interruption is limited to a minimum amount of time and at off peak hours. When a new span, catenary, and tether are to be installed on an existing structure, the work shall be done so as not to damage the structure. ~~Tether cable will not be required on a flasher installation.~~ If an existing structure is damaged, it shall be repaired or replaced as directed with no additional payment. The new span and catenary installation shall not interfere with the operation of the existing traffic signal. Traffic shall be controlled at all times during the changeover when the existing traffic signal is turned off and the new signal is turned on. This changeover shall take place such that the interruption is limited to a minimum amount of time.

When directed, temporary stop signs shall be erected at the intersection. When no work is in progress, the intersection shall have at least 2 operating signal faces for each approach. When the new installations are completed, all existing signal equipment and materials including wood poles, steel poles, and cast-iron handhole rings and covers which have not been used in the new installation shall be carefully removed. Regardless of the right to materials found on the project, as set out in other sections of these specifications, items designated in the contract documents, and field identified by the Department, as traffic signal equipment to be salvaged by the Department or local unit of government shall be stored at a secure site until such time as it is transported to the ~~District Office~~ *designated location*, when designated as a pay item, or salvaged by the Department or local unit of government. The Contractor shall verify that the field identification placed by the Department has not been removed by vandalism or natural causes. If the Contractor has reason to believe field identifications have been removed, it shall contact the Department. The Contractor shall be responsible for all damage or loss of this equipment and shall repair or replace the damaged or lost equipment as directed. All signal equipment removed and not designated to be salvaged shall become the property of the Contractor and shall be disposed of in accordance with 202.

All existing painted signal equipment to be reused, such as pedestals, bases, controller cabinets, signal heads, signal weatherheads, pipe arms, shall be cleaned and

painted with ~~two~~2 coats of highway yellow enamel. Aluminum poles and ~~mast arms~~signal support structures shall not be painted.

Existing concrete foundations, which have not been used in the new installation, shall be removed to a minimum of 4 in. (100 mm) below the adjacent grade. The openings shall be filled with concrete and the surface finished and broomed, if they are located in sidewalk areas. Otherwise, they shall be filled with acceptable material conforming with the surrounding area. Existing signal handholes to be removed, shall be filled after removing rings and covers, with B borrow with a minimum of 4 in. (100 mm) of concrete on top to bring it up to grade in a sidewalk area. Surfaces shall be finished and broomed. Otherwise, they shall be filled with acceptable material conforming with the surrounding area.

The signal controller timings will be provided and the Engineer shall be present when the signal intersection is to be placed in operation.

All electrical wiring terminations and splices; controller and cabinet set-up; and testing, review, and turn-on of all operational apparatus at each location shall be done by or in the presence of and under the responsible charge of an employee of the Contractor who holds a Traffic Signal Construction Technician Level II certification which has been granted by the International Municipal Signal Association. Installation inspections, troubleshooting, maintenance and repair of these systems shall be accomplished by or in the presence of and under the responsible charge of an employee of the Contractor who holds a Traffic Signal Construction Technician Level II certification or a Traffic Signal Field Technician Level II certification which has been granted by the International Municipal Signal Association. Supervision of non-electrical, traffic signal related construction work and traffic control shall be done by a person holding, at a minimum, a Work Zone Traffic Safety Specialist certification which has been granted by the International Municipal Signal Association, or an equivalent certification approved by the Department.

Before starting work, the Contractor shall provide the names of the Level II Traffic Signal Construction Technicians, the Level II Traffic Signal Field Technicians and Work Zone Traffic Safety Specialists who have been assigned to perform signal related work, and a photocopy of each such person's certification card. If the Level II Traffic Signal Construction or Field Technicians or Work Zone Traffic Safety Specialists are dismissed from the work, all signal related work requiring such certified personnel on the project site shall cease until the names and photocopies of certification cards for replacement personnel are provided to the Engineer.

Electrical work shall be executed in accordance with the requirements of the National Board of Fire Underwriters, the State Fire Marshal, and the power company which will furnish the electric service. The work shall be in accordance with any local regulations that may apply. The Department will arrange and provide for power service which the power company will bring to the point designated on the plans. Prior to the start of construction, the schedule of activities shall be coordinated with the power company and they shall be contacted again at least 14 days prior to the time the service work is to be completed.

The Department will obtain permits from local officials, companies, or individuals for the use of poles, right-of-way, or other property incidental to the installation of traffic signal. Although entering into the contract implies permission and authority to cut into and push under pavement, sidewalks, and alleys, any damage to underground utilities or interruption of such service shall be the responsibility of the Contractor. The Contractor shall be in accordance with local regulations as well as 107.08. Protective devices shall be in accordance with 107.12 and 801.

The location of signal heads, controllers, signal poles, signal cantilever structures, detector housing, disconnect hangers, and other installation items will be shown on the plans. However, a change in the location of an item may be ordered during the progress of the work. The work shall be completed as shown on the plans except for those changes specifically authorized in writing.

Flashing beacons shall flash at a rate for each beacon of 50 to 60 times per minute with the illuminated period from 1/2 to 2/3 of the total cycle. If a second beacon is specified, the 2 beacons shall flash alternately.

805.04 Pole Installation

Working drawings for strain poles or cantilever structures shall be provided in accordance with 105.02. Metal poles shall be erected on concrete foundations and shall be reasonably plumb after installation of signal heads. The handhole side of the pole shall be at right angles to the direction of the ~~mast~~ signal cantilever arm or span, catenary, and tether. Signal cables shall be brought up inside the poles. Any steel pole, ~~mast~~ signal cantilever arm, or hardware not galvanized or painted with baked enamel shall be painted with ~~2 coats of rust inhibiting aluminum paint~~ structural steel coating system in accordance with 619.09(a). The surface shall be prepared in accordance with 619.08(a), 619.08(b) and 619.08(d). Paint shall be applied in accordance with 619 ~~with the exception that commercial blast cleaning of the steel will not be required~~. All rust, scale, and dirt shall be cleaned from the metal surface so that paint adheres to the surface.

The construction of concrete foundations shall be in accordance with 805.13. Wood poles shall be set a minimum of 7 ft (2.1 m) in the ground and raked 12 in. (300 mm).

805.05 Placing Signal Heads

~~Mast~~ Signal cantilever arm and span mounted signal heads shall have 17.5 ft (5.23 m) minimum and 19 ft (5.8 m) maximum clearance over the roadway unless there are visual obstructions which require lowering the signal head. A signal head over the roadway shall not have a clearance of less than 15 ft (4.6 m). Such signal heads shall be located over the intersection as shown on the plans. Such signal heads shall have a uniform clearance, which will be determined. Signal heads not mounted over a paved roadway, on the top or side of a pole, shall not be less than 10 ft (3 m) nor more than 15 ft (4.6 m) above the sidewalk or, if none, above the pavement grade at the center of the roadway. Signal faces shall be directed to the proper approach lane in each direction. *Flasher signal faces that supplement signs shall be mounted with the bottom of the housing at not less than 3 ft (0.9 m) nor more than 13 ft (3.9 m) above the edge of*

pavement. Flasher signal faces that supplement signs shall be directed towards oncoming traffic. Pedestrian signal faces shall be mounted with the bottom of the housing at not less than 7 ft (2.1 m) nor more than 10 ft (3 m) above the sidewalk. The pedestrian signal shall be in line with the pedestrian's vision at the appropriate crosswalk being used. Pedestrian push-buttons shall be mounted at a height of 3 1/2 to 4 ft (1.1 to 1.2 m) above the sidewalk as shown on the plans. A pedestrian actuated signal sign shall be mounted immediately above the push-button.

Signal heads shall be assembled and wired with 1 conductor, *type* THW, stranded wire. Where splices are made, a 2 ft (0.6 m) minimum length of cable or wire in excess of that required for a continuous run shall be provided. Splices shall be twisted together and soldered or approved type connectors used. Each splice shall be completely insulated by wrapping with an approved tape and sealed with an approved electrical coating material. Splices shall be made in such manner that the connections are moisture proof. The cables coming out of the signal weatherhead shall be looped to form a drip loop. The drip loop shall be made so that the cables coming out of the weatherhead loop down below the elevation of the weatherhead to prevent water from following the cable into the weatherhead. If used, the splice indicated above shall be located in the top of the coils of cable forming the drip loop.

Signal heads shall not be installed until all other work has been completed. If it becomes necessary to mount signal heads for more than 2 h before the lights are to be turned on, the signal heads shall be hooded by placing sacks or similar cover over them so as to conceal them from traffic. Hooded signal heads are not permitted to be in place for more than 5 days. No signal head shall be left over night with the lights out unless it is hooded. Signal heads shall be securely mounted. The polycarbonate signal face shall be used only when securely supported on both ends of the assembly. In a span cable installation, a tether cable would satisfy this requirement.

805.06 Grounding

All signal supports, signal controller supports, and entrance switches shall be grounded in accordance with the applicable requirements of 807.12.

805.07 Wire and Cable Installations

All cable runs attached to utility poles shall have code clearance relative to utility cables. They shall be no less than 18 ft (5.5 m) above the ground level except over railroad tracks when a minimum of 27 ft (8.2 m) clearance shall be maintained. All cable runs shall be installed in continuous lengths without splices between terminals except when necessary at handholes, junction boxes, pole signal bases, and pedestal bases. The type of cable and the number of conductors as well as the gage shall be as shown on plans unless otherwise specified.

Cable rings shall be used to support the signal cable on the signal span cable. They shall be spaced 12 in. (300 mm) on center. Cable shall be pulled through the conduit to the terminal panel in the controller cabinet. Caution shall be used to prevent damage to the cable when it is being pulled through conduit.

Coded cable conductors shall be used throughout the installation. Cable conductors shall be tagged at all detector housings, handholes, pole signal pole bases, and controller cabinets. *At the ends of each cable, the tag shall be placed between 4 and 8 in. (100 and 200 mm) from the end of the wire and on the outer jacket. At all other locations, the tag shall be placed in the middle of the length of cable stored at the location. The tag shall be 1/2 in. (13 mm) wide, thermal printed black on yellow or black on white, polyester or nylon tape with permanent adhesive and shall be water, chemical and scratch resistant. The font shall be arial, size 10. Tags shall be installed flag style around the cable with the backs of the tag ends placed together. Tags shall consist of an aluminum blank of sufficient size to be stamped with not less than 3/16 in. (5 mm) high all upper case letters which identify the cables by their use and phase. The following are the uses which shall be indicated by the tags:*

- (a) Power
- (b) Pedestrian Signal
- (c) Pedestrian Actuation
- (d) Signal-Phase Identification
- (e) Detection Loop Identification
- (f) Interconnect

Signal cables shall be tagged to identify the direction of travel. Detector lead-in cables shall be tagged throughout the installation with the corresponding loop tag information.

~~Loop identification shall consist of the following:~~

~~Inside of the Detector Housing, the loop wires of each loop shall be tagged with, in _____, out _____, as shown on the plans.~~

~~Loop Number — Loop Number~~

~~Inside of the Controller Cabinet, each lead-in cable shall be tagged within 6 in. (150 mm) of the terminal strip connection with: Lane designation, Phase Number, Loop Number, and when applicable with loop system number, and speed trap according with the plans.~~

~~Phase identification shall consist of the single number "1", "2", "3", etc., which corresponds to the phase diagram for the respective intersection. Tags shall be securely fastened to the cable with a non-corroding material. The tagging material and fastening shall be approved prior to proceeding with this work. The color coded wires shall be connected properly. The white wire shall be the common or ground. Wire used for all identical indications of any individual phase shall be color coded and, where possible, shall use red wire to connect red lenses, orange wire to connect yellow lenses, and green wire to connect green lenses. Signal heads shall be assembled and wired before being~~

installed. The testing of the loops shall be documented in the Loop Testing Table provided by the State.

805.08 Controller Cabinet, Signal Service, and Detector Housing Installation

Three document packets shall be prepared in accordance with 922.02(b) for each cabinet. Each packet shall be labeled with the name of the contract number, the intersection, the commission number of the signal, and the date of installation. One packet shall be placed in the cabinet and the remaining 2 packets shall be submitted to the Engineer within 2 days after the signal is turned on. Information in the packets shall include all approved changes to the signal installation. All detector loop lead-in tags and detector rack labels shall reflect all approved changes to the signal installation.

Additional detector loop amplifier units and detector racks shall be supplied as directed by the Engineer. Additional detector racks shall include all cables or harnesses including, but not limited to a SDLC cable for each added rack, interface panels and a BIU to provide a complete and functional installation. Additional auxiliary BIU panels shall include all cables or harnesses including, but not limited to a SDLC cable for each additional auxiliary BIU panel, terminal strip on BIU panel and BIU to provide a complete and functional installation.

For signal cabinets installed by the Contractor, where no detector loop or lead-in work is included in the contract, the Contractor shall perform detector loop tagging, testing and vehicle simulator testing in accordance with 805.09, only to the extent of documenting the test readings and confirming that all existing detector loops are connected correctly and all detector related equipment in the cabinet is operating correctly.

The controller cabinet shall be mounted securely on a pole, pedestal, or concrete foundation. All cabinets on concrete foundations shall be installed with the anchor bolts inside. Controller cabinets on poles or pedestals shall be mounted at a height of 38 in. \pm 2 in. (970 mm \pm 50 mm). Pole mounted controller cabinets shall be fastened with 2 stainless steel bands as shown in the plans. Signal cables and lead-in cable shall be run in conduit from the controller cabinet to the signal support base and to detector housing as indicated on the plans. Galvanized steel elbows shall be used on the detector housing as shown on the plans.

The Contractor shall wire the entrance switch and bring service cable up the riser and out the weatherhead and leave 4 ft (1.2 m) of cable outside the weatherhead. The utility company, at their option, may bring the service cables to the load side of the entrance switch. Meter bases, if required, shall be obtained from the power company ~~and any service connection or miscellaneous charges shall be assumed by the Contractor.~~

A minimum of 12 in. (300 mm) and a maximum of 18 in. (450 mm) of loop wire duct will be permitted in the detector housing for each loop lead. Concrete used in the installation of detector housings shall be in accordance with 506, except 506.05 will not apply. A CMDS in accordance with 502.03 shall be submitted, however, utilization of the Department provided spreadsheet is not required. Where a portion of the road is closed or where there is no vehicular traffic, then class A concrete in accordance with 702 may be

used. The concrete shall be placed flush with existing surface and shall be covered with a steel plate during the setting time.

805.09 Loop Wire Detector Installation

This work shall consist of placement and testing of loop wire detectors in accordance with the installation details shown on the plans.

MATERIALS

~~Loop wire shall be in accordance with 922.06(e)7b. Loop detector sealant shall be in accordance with 922.06(e)7c.~~

(a) Layout

The number, size, arrangement, and locations of loops shall be as shown on the plans except that loop spacing shall be adjusted to avoid PCCP joints. Loops shall be of a regular octagon shape with sides of 2 1/2 ft (0.75 m) in length or a circular shape with a diameter of 6 ft (1.8 m). Loops placed longitudinally adjacent in the same lane shall be spaced 15 ft (4.57 m) from the center of one loop to the center of the next loop. Loops shall be arranged so that no loop wire will be bent at an angle less than 120°. Regardless of configuration, the loop installation shall match the intention of the loop tagging table.

~~Loops Prior to installation, loop layout shall be of a regular octagon shape with side of 2.5 ft (0.75 m) approved in length. An outline shall be laid out and painted where the loops shall be sawed. The loop locations shall be subject to the review and approval of the writing by the District Traffic Engineer. The Contractor shall notify the District Traffic Engineer shall be notified 48 h a minimum of 2 business days prior to such field review the date that loop layout approval is required. All roadway centerlines, edge-lines and stop-bars pertinent to loop layout shall be accurately and clearly identified at the time loop layouts are reviewed for approval. An outline shall be painted where the loops are to be placed. The Contractor shall ensure that the final installed location of each loop matches the intention and functionality of the approved layout for loop spacing, lane width and geometry.~~

(b) Installation

All loops and lead-in cables shall be tagged according to the plans and 805.07.

1. Saw-cut Loops

The slots shall be saw-cut as shown on the plans. A diamond cutting blade shall be used for sawing all loops. All saw-cut loops shall have individual saw cuts to the detector housing. Joints shall be overlapped such that the saw cut at the corner is full depth. ~~Slots shall be thoroughly cleaned and dried before the installation of loop wires.~~ Prior to installing roadway loop wire in the roadway saw cuts, the saw cuts shall be cleaned in accordance with the manufacturer's requirements for the joint sealant to be used. After proper cleaning, the loop wire shall be installed. All loops shall be wired clockwise as viewed from above. Loops shall be wired with 4 turns or as specified then gently tamped with a blunt non-metallic tool. Backer rod 2 to 4 in. (50 to 100 mm) in length shall be spaced every 12 in. (300 mm) around the saw cut above the wire and gently tamped to hold the loop wire snugly in the bottom of the saw cut. Backer rod shall

not be continuous around the saw cut. After installation of the loop wire, the saw cut shall be sealed with a joint sealant material. The sealant shall be poured into the saw cut making a water tight seal. The joint sealant material shall be installed in accordance with the manufacturer's recommendations and 906.02. However, the joint configuration shall not apply. A copy of the sealant manufacturer's written application instructions shall be submitted to the Engineer prior to any sealant operations. If the Contractor elects to use a sealant complying with 906.02(a)2, the sealant material shall be heated in a kettle or melter constructed as a double boiler with the space between the inner and outer shells filled with oil or other heat-transfer medium. This melter shall have a positive temperature control and a mechanical agitator. A backer rod shall be used for both cold applied sealants and hot poured sealants. The sealant material shall fill the saw cut as shown on the plans. All excess joint sealant on the pavement surfaces shall be promptly removed.

~~The specified number of turns shall be placed in the slot and gently tamped with a blunt non-metallic tool. A sash cord or backer rod shall be placed above the wire after tamping. The number, size, arrangement, and locations of loops shall be as shown on the plans. Loop spacing shall be adjusted to avoid pavement joints. Loop wire shall be pressed into the saw slot with a blunt non-metallic tool. Loop wire shall only be bent at angles of 120° or greater. All loops shall be wired clockwise as viewed from above. Loops shall be wired with 4 turns and in a series unless otherwise specified. Joints shall be overlapped such that the saw cut at the corner is full depth. The sealant shall be poured into the saw cut making a water tight seal. The splice of the loop wire and lead in cable shall be soldered and waterproofed at the detector housing. Waterproofing shall consist of the use of heat shrink tubing which has an internal coating sealant material. The heat shrink tubing shall not be heated by means of a direct flame tool. Loop wire and lead-in cable shall be tagged according to the plans and 805.07. The black lead-in wire shall be spliced to the loop wire which goes back to the field. Such wire shall be tagged as "Out/Loop (No.)". The white lead-in wire shall be spliced to the loop wire which comes in from the field. Such wire shall be tagged as "In/Loop (No.)".~~

2. Preformed Pavement Loops

Preformed pavement loops may be installed as a 1, 2, 3 or 4 loop configuration. Pavement loops shall be secured in place prior to paving.

(c) Splices

For each loop cable and lead-in cable entering a handhole, there shall be 6 ft (1.8 m) of cable jacket remaining on each wire after the splice is complete. For each loop cable and lead-in cable entering a detector housing, there shall be 2 ft (0.6 m) of cable jacket remaining on each wire after the splice is complete. For all loop splices, there shall be a maximum of 1/2 in. (12 mm) of non-jacketed wire measured from the end of each cable jacket to the edge of the splice waterproofing material. The splice of the loop wire and lead-in cable shall be soldered and waterproofed at the detector housing or handhole. Waterproofing shall consist of the use of heat shrink tubing which has an internal coating sealant material. The heat shrink tubing shall not be heated by means of a direct flame tool.

(d) Testing and Acceptance

All testing and acceptance procedures performed by the Contractor shall be performed in the presence of the Department personnel assigned by the Engineer. The Contractor shall notify the Engineer a minimum of 2 business days prior to the date testing is to be performed.

TESTING

The Contractor shall meter all new loop wire detectors or a new bank of loop wire detectors by means of instruments capable of measuring electrical values for installed loop wires and lead-in cables. The instruments shall measure inductance in microhenries, resistance in ohms, induced A.C. voltage in volts, and leakage resistance in megohms. All measuring tests shall be performed at the detector housing before the loop wire is spliced to the lead-in cable, and at the cabinet after the loop wire is spliced to the lead-in cable.

1. Electrical Testing

(a) a. Megohm Test Before Splice is Made at Detector Housing for Loop Wire

One of the megohm probes shall be connected to ground and the other probe shall be connected to the “in” or “out” loop wire. The remaining loop wire shall be isolated. The test shall then be performed.

(b) b. Megohm Test Before Splice is Made at Detector Housing for Lead-in Cable

~~The 2 wires of the lead-in cable at the cabinet shall be twisted together and taped. The shield of the lead-in cable shall be grounded in the cabinet. At the detector housing, 1 megohm probe shall be connected to ground and the other probe shall be connected to 1 of the lead-in wires. The remaining lead-in wire shall be isolated. The test shall then be performed.~~

The 2 wires and shield of the lead-in cable at the cabinet shall be isolated and taped. The test shall consist of recording 4 readings taken at the detector housing or handhole as follows:

- (1) Connect the 1st megohm probe to ground and the 2nd probe to the shield. Record the reading.*
- (2) Connect the 1st megohm probe to the 1st lead-in wire and the 2nd probe to the shield. Record the reading.*
- (3) Connect the 1st megohm probe to the 2nd lead-in wire and the 2nd probe to the shield. Record the reading.*
- (4) Connect the 1st megohm probe to the 1st lead-in wire and the 2nd probe to the 2nd lead-in wire. Record the reading.*

The lowest of the 4 readings taken above shall be recorded on the testing document for acceptance.

(e) c. Megohm Test After Splice is Completed at Cabinet

This test shall be performed after the splice at the detector housing is completed. A water solution of 1 tablespoon (15 ml) of baking soda per pint (0.5 L) of water shall be placed in a metal container. The metal container shall be grounded and the splice shall be fully submerged in the solution for 2 min. With the splice submerged, the *shield of the lead-in shall be connected to ground at the cabinet. One megohm probe shall then be connected to ground and the other probe connected to one of the lead-in wires* ~~test shall be performed at the cabinet on the end of the lead in cable and the reading recorded.~~

~~(d) Vehicle Simulator Test~~

~~This test shall be performed after all other tests are completed and after all connections have been made at the controller in the cabinet. This test shall be performed by dragging a test vehicle across the loops using a non-conducting string. The test vehicle shall be fabricated with an 8 ft (2.4 m) length of No. 6 bare copper wire formed into a circle. The 2 ends shall then be electrically spliced. The detector unit amplifier shall record a call as the test vehicle is dragged across the loop. It shall cancel the call as the test vehicle leaves the loop.~~

2. Delay Amplifier Settings and Vehicle Simulator Test

After all detector loop testing is complete, the detector amplifiers shall be installed and settings adjusted for proper operation at the intersection.

The frequency setting shall be adjusted using the amplifier's display so that adjacent loops in the roadway that are connected to different loop amplifiers have a minimum difference of 5 kHz. This operating frequency setting does not apply to loops that are adjacent to each other in the roadway but are connected to the same loop amplifier.

The sensitivity setting shall be adjusted using the amplifier's display. With an average size front wheel drive vehicle with the front axle centered over the back loop of a series of loops, the sensitivity shall be adjusted in accordance with the manufacturer's recommendations.

The count output shall be enabled for all loops designated as counting loops. The number of loops setting shall be set for loops designated for counting purposes and shall be set to the number of loops connected to that loop amplifier.

This test shall be performed by dragging a test vehicle across the loops using a non-conducting string. The test vehicle shall be fabricated with an 8 ft (2.4 m) length of No. 6 bare copper wire formed into a 2 1/2 ft (0.76 m) diameter circle. The 2 ends shall then be electrically spliced. The test shall be started with all detector amplifiers turned 'Off' except for one (1) approach. All amplifiers for that approach shall be turned 'On' and adjusted to the proper settings. All traffic for the approach being tested shall be stopped and not allowed to cross any loops during the test procedure for that approach. The simulator shall be dragged slowly across each loop system in the same direction as to simulate a vehicle driving through the loop system. As the simulator crosses each loop an IMSA level II certified Signal Technician shall verify that a call is displayed

exclusively on the corresponding loop amplifier, controller detector input and controller phases. After completely verifying the loops on the first approach the amplifiers shall be left 'On', and the amplifiers for the next approach to be tested shall be turned 'On' and adjusted to the proper settings. The same procedure shall be followed for each remaining approach. With large intersections, as the test proceeds, it may become difficult to verify that the calls are going to the correct detector inputs. In this case, traffic control shall be used to stop vehicles before reaching the loops for as many approaches as needed to accurately complete the testing to the inspector's approval. Testing may be paused between lanes to allow traffic to clear.

(e) 3. Acceptance Criteria

The Contractor shall record all test readings, in triplicate, on tabular forms provided by the Department or by copying the 1 included elsewhere herein. The Contractor shall complete, sign, and date the forms before submitting them to the District Traffic Engineer. The District Traffic Engineer will use these forms for recording the Department's readings on the corresponding space provided.

In order for the loop detector installation to be accepted, the electrical values shall be as follows:

- ~~1.~~ a. Inductance shall be between 80 and 800 μ H. Inductance shall be determined by means of digital readout meter which drives the field loop system.
- ~~2.~~ b. Resistance shall be less than or equal to 8 ohms.
- ~~3.~~ c. ~~Induced AC voltage~~ Voltage shall be less than or equal to 3 V.
- ~~4.~~ d. ~~Induced A.C. voltage and leadage~~ Leakage resistance shall be greater than 100 megohms.

Loop wire and/or lead-in cable failing to meet this requirement shall be replaced at no cost to the State.

805.10 Magnetometer and Microloop Detectors

(a) Testing

Before installation of ~~M~~magnetometer or ~~M~~microloop probes the Contractor shall confirm the adequacy of the magnetic field intensity, to be sure that the range is suitable for their operation.

The Contractor shall demonstrate that the microloop count data recorded in the controller's detector log is within 5% of count data obtained visually over a 15-minute period for every detector installation. The test shall be performed by the Contractor in the presence of the Engineer. If detector sensitivity or calibration settings are adjusted in order to meet this test, the new settings shall be recorded on the wiring diagram in the cabinet.

(b) Installation

Arrangement of probes shall be located at maximum distance from ~~steel support~~ ~~under bridges~~ *metal objects as per manufacturer's recommendation*. Probes shall be installed with their long dimension vertical, and with the cable end at the top. Probes shall be firmly supported, so the lateral and vertical motion is restricted. Probes shall be connected in series. The splice shall be soldered by means of hot iron, or pouring or dripping without flames, with rosin core solder and shall be insulated and waterproofed in accordance with the manufacturer's specifications.

PVC conduit for the microloop detector probes shall be directionally pushed beneath the pavement at the depth and slope determined by the manufacturer to ensure proper carrier and probe installation. The Contractor shall repair any damage to the pavement that occurs during the installation. The microloop detector probe location in each lane shall be per the manufacturer's recommendation.

805.11 Steel Conduit

Conduit shall be installed to a depth of no less than 2 ft (0.6 m) or more than 5 ft (1.5 m) below the finished grade unless otherwise specified or approved. Pockets or traps where moisture might accumulate shall be avoided. Conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission. If permission is granted, cuts in pavement areas shall be no greater than 24 in. (600 mm) wide. All cuts in the pavement and sidewalk areas shall be sawed. Sidewalk removal and replacement shall be to the nearest tooled joint. Jacking and drilling pits shall be kept at least 2 ft (0.6 m) clear of the edge of any type of pavement or paved shoulder. Excessive use of water that may cause undermining of the pavement shall be avoided. Continuous conduit runs shall not exceed 250 ft (76 m) in length, unless otherwise indicated on the plans.

Expansion fittings as detailed on structure plans shall be installed where conduit crosses an expansion joint in the structure. Where it is deemed inadvisable to install expansion fittings in closely confined areas, the installation of approved flexible tubing may be permitted. Such expansion joints or tubing shall be the same size as the conduit. Any existing underground conduit to be incorporated into a new signal installation shall be cleaned with a mandrel and blown out with compressed air before cable is drawn into pipe. All new conduit runs shall be cleaned and swabbed before cables are installed. All conduit ends shall be capped and shall remain capped until the Contractor is ready to pull cable into the conduit, at which time the caps shall be removed and conduit bushings placed on each end to protect the cable. The inside surface of the conduit shall be kept clean. Conduit to be installed, indicated on the plans for future use of signal cables, shall be left in place with a pull cord on its entire length.

Larger size conduit may be used with no additional payment, but when it is used, it shall be for the entire length of the run from outlet to outlet. Conduit runs as shown on the plans are for bidding purposes only and may be changed, with permission, to avoid underground obstructions. A change order may be authorized if the conduit runs can be made on the opposite side of the street to that shown on the plans in order to avoid obstruction and traffic inconvenience or to avoid unnecessary tearing up of existing pavement.

805.12 PVC and Fiberglass Conduit

The method of installing PVC and rigid fiberglass conduit underground shall be the same as for steel conduit where applicable except trenches for the conduit shall be backfilled with 2 in. (50 mm) of sand before the conduit is placed in the trench. Materials excavated may be used for backfill, if approved. If the Engineer deems it necessary, approved B borrow shall be placed over the conduit to a depth of 12 in. (300 mm) and the remainder of the trench shall be filled with excavated material.

Schedule 40 PVC or rigid fiberglass conduit may be used for conduit placed in trenches. Schedule 80 PVC shall be used for conduit that is jacked or bored.

805.13 Foundations

Foundations for traffic signal poles, structures, cabinets, and pedestals of the type specified shall be constructed, or existing M foundations shall be modified, as shown on the plans or as directed. Pedestal bases shall be plumb and firmly attached to the anchor bolts either by using leveling nuts or shims if top of the foundation is not level. Grouting shall be used when necessary to fill any gap between pedestal base and foundation. Pipe pedestals shall be screwed tightly into the bases and secured with a stainless steel pin. Power and signal cables shall then be pulled from the base into the cabinet. Curing of concrete shall be in accordance with 702.22.

Foundations for traffic signal cantilever structures shall be constructed as shown on the plans or as directed. The foundation concrete shall be placed monolithically and shall have no construction joint. Structure bases shall be plumb and attached to the anchor bolts using leveling nuts. A tooled line or other type of permanent marking shall be provided on the top of the foundation to indicate the direction of the conduits. Curing of concrete shall be in accordance with 702.22.

During excavation of the foundation, all material shall be removed to the full depth as shown on the plans, except if class X material is encountered, the work shall be performed in accordance with 206.02(b).

805.14 Final Clean-Up

When the installation is completed, all disturbed portions of sidewalk, pavement, shoulders, driveways, sod, etc., shall be cleaned and any excess excavation or other materials shall be disposed. All cutting in the sidewalk and pavement areas shall be done with a saw. Sidewalk removal and replacement shall be to the nearest tool joint. Unless otherwise directed, cuts in pavement areas shall be no greater than 12 in. (300 mm) in width.

805.15 Method of Measurement

Traffic signal head; pedestrian signal head; pedestrian push button; controller cabinet foundation; M foundation modified to P-1 foundation; signal steel strain pole; signal wood pole; ~~signal cantilever structure~~, signal cantilever structure, signal arm; signal cantilever structure, combination arm; signal cantilever structure, pole section 2, pole diameter 17 in. (432 mm); signal cantilever structure, pole section 2, pole diameter 24 in. (610 mm); signal cantilever structure, drilled shaft foundation type; signal cantilever structure, spread footing foundation type; signal support foundation; signal

service; disconnect hanger; magnetometer detector; microloop detector; loop detector delay amplifier; *loop detector delay counting amplifier; loop detector rack; auxiliary BIU panel; signal handhole; signal detector housing; span catenary and tether; and span catenary for flasher* will be measured by the number of units installed.

The pay length for a signal cantilever arm or combination arm will be the length shown in the Schedule of Pay Items.

Conduit of the type specified will be measured by the linear foot (meter) from outside to outside of foundations. Signal cable and signal interconnect cable will be measured by the linear foot (meter).

Performed pave-over loops will be measured by the number of loops placed. Each loop will be measured only once, regardless of the number of signal cable turns. Signal cable from performed pave-over loops to handholes, detector housings or from loop to loop will not be measured for payment.

The accepted quantities for payment for electrical signal or loop lead-in cable will be the quantities shown in the Schedule of Pay Items. Such quantities may be corrected if they are in error by more than 25%.

Saw cut for roadway loop detector and sealant will be measured by the linear foot (meter) for the full depth of slot cut in the pavement as shown on the plans or as directed.

If class X material is encountered during foundation excavation, measurement will be made in accordance with 206.10.

Traffic signal installation or modernization, flasher installation or modernization, miscellaneous equipment for traffic signals, and final cleanup in accordance with 805.14 will not be measured for payment.

Traffic signal equipment removal ~~and~~ *will be measured per each installation to be removed.* ~~Transportation of salvageable signal equipment will not be measured.~~

805.16 Basis of Payment

Traffic signal installation, flasher installation, traffic signal modernization, and flasher modernization, all of the type and the location number specified, will be paid for at a contract lump sum price.

If specified as pay items, traffic signal controller and cabinet; traffic signal head; pedestrian signal head; pedestrian push button; controller cabinet foundation; M foundation modified to P-1 foundation; signal steel strain pole; signal wood pole; ~~signal cantilever structure; signal cantilever structure, signal arm; signal cantilever structure, combination arm; signal cantilever structure, pole section 2, pole diameter 17 in. (432 mm); signal cantilever structure, pole section 2, pole diameter 24 in. (610 mm); signal cantilever structure, drilled shaft foundation type; signal cantilever structure, spread footing foundation type;~~ signal support foundation; signal pedestals; signal service; disconnect hanger; magnetometer detector; microloop detector; loop detector

delay amplifier; loop detector delay counting amplifier; loop detector rack; auxiliary BIU panel; signal handhole; signal detector housing; span catenary and tether; and span catenary for flasher will be paid for at the contract unit price per each. Conduit of the type specified, signal cable, interconnect cable, electrical signal cable, loop lead-in cable, and saw cut for roadway loop detector and sealant will be paid for at the contract unit price per linear foot (meter).

Performed pave-over loops will be paid at the contract unit price per each.

The removal of existing traffic signal equipment designated to be removed will be paid for at the contract ~~lump sum~~ *unit price per each* for traffic signal equipment, remove for each location removed. When designated as a pay item, the transportation of salvageable signal equipment will be paid for at the contract lump sum price for transportation of salvageable signal equipment.

Class X excavation will be paid for in accordance with 206.11.

Miscellaneous equipment for traffic signals will be paid for at a contract lump sum price.

Payment will be made under:

Pay Item	Pay Unit Symbol
<i>Auxiliary BIU Panel</i>	<i>EACH</i>
<i>Conduit</i> _____ <i>type</i>	<i>LFT (m)</i>
Controller and Cabinet, _____, _____ Phase..... <i>type no.</i>	<i>EACH</i>
Controller and Cabinet, Flasher, _____ <i>type</i>	<i>EACH</i>
Controller Cabinet Foundation, _____ <i>type</i>	<i>EACH</i>
Controller Cabinet Foundation, M, Modify to P-1	<i>EACH</i>
Disconnect Hanger	<i>EACH</i>
Flasher Installation, Location No. _____	<i>LS</i>
Flasher Modernization, Location No. _____	<i>LS</i>
Handhole, Signal	<i>EACH</i>
Loop Detector Delay Amplifier, _____ Channel..... <i>no.</i>	<i>EACH</i>
Loop Detector Delay <i>Counting</i> Amplifier, _____ Channel	<i>EACH</i>
<i>Loop Detector Rack</i>	<i>EACH</i>
Magnetometer Detector.....	<i>EACH</i>
Microloop Detector <i>Probe</i>	<i>EACH</i>
Miscellaneous Equipment for Traffic Signals.....	<i>LS</i>
Pedestrian Push Button	<i>EACH</i>
Pedestrian Signal Head, _____, _____	<i>EACH</i>

	type lens size	
Saw Cut for Roadway Loop and Sealant		LFT (m)
Signal Cable, _____, No. _____ Copper, _____ C/ _____		LFT (m)
	type conductors/size	
<i>Signal Cable, Preformed Pave-Over Loop</i>		<i>EACH</i>
Signal Cantilever Structure, Mast Arm _____ ft (m)	length	EACH
<i>Signal Cantilever Structure, Signal Arm _____ ft (m)</i>	<i>length</i>	<i>EACH</i>
<i>Signal Cantilever Structure, Pole Section 2,</i>		
<i>Pole Diameter 17 in. (432 mm).....</i>		<i>EACH</i>
<i>Signal Cantilever Structure, Pole Section 2,</i>		
<i>Pole Diameter 24 in. (610 mm).....</i>		<i>EACH</i>
<i>Signal Cantilever Structure, Combination Arm _____ ft (m)</i>	<i>length</i>	<i>EACH</i>
<i>Signal Cantilever Structure, Drilled Shaft Foundation, _____</i>	<i>type</i>	<i>EACH</i>
<i>Signal Cantilever Structure, Spread Footing Foundation, _____</i>	<i>type</i>	<i>EACH</i>
Signal Detector Housing		EACH
Signal Interconnect Cable, _____, No. _____	type	
	Copper, _____ C/ _____	LFT (m)
	conductors/size	
Signal Pedestal, _____ ft (m)	length	EACH
Signal Pole, Wood, _____, _____ ft (m)	class length	EACH
Signal Service.....		EACH
Signal Strain Pole, Steel, _____ ft (m).....	length	EACH
Signal Support Foundation, _____ in. (mm) x _____ in. (mm)		
x _____ in. (mm).....		EACH
Span and Catenary for Flasher		EACH
Span, Catenary, and Tether		EACH
Traffic Signal Equipment, Remove.....		LS EACH
Traffic Signal Head, _____ Way, _____ Section, _____	no. no. lens sizes & colors.....	EACH
Traffic Signal Installation, _____, Location No. _____	type	LS
Traffic Signal Modernization, _____, Location No. _____	type	LS
Transportation of Salvageable Signal Equipment.....		LS

The cost of the solar panel, battery cabinet, program timing module, signal heads, wiring, and all hardware required to complete the installation shall be included in the cost of flasher installation or flasher modernization.

The cost of all wiring, hardware, anchor bolts, and associated equipment required to operate the intersections shall be included in the cost of controller and cabinet, flasher.

The cost of signal face hook-up wire, pole plates and arms for side mounts, mid-mast arm mount, pipe arms, signal brackets, visors, louvers, bulbs, span hanger, backplates, balance adjuster, weatherhead, and all additional hardware required to assemble a combination of signal faces as shown on the plans shall be included in the cost of traffic signal head or pedestrian signal head.

The cost of the push button, pedestrian actuated signal sign, and all hardware required to complete the installation shall be included in the cost of pedestrian push button.

The cost of concrete, conduits, grounding bushings, ground rod, ground wire, drainage, and all hardware required to complete the installation shall be included in the cost of controller cabinet foundation.

The cost of the base plate, metal skirt base plate, anchor bolts, handhole and cover grounding lug, 2 in. (50 mm) pipe cable entrance, J hook, and top cover as shown on the plans shall be included in the cost of signal strain pole, steel.

The cost of downguys, anchor rods, downguy guards, and hub-eyes as shown on the plans, and all hardware required to complete the installation shall be included in the cost of signal pole, wood.

The cost of all hardware including the metal skirt base plate, where necessary, to complete the installation as shown on the plans shall be included in the cost of signal cantilever structure.

The cost of signal pole section 1 shall be included in the cost of the signal cantilever structure.

The cost of concrete, reinforcing steel, conduits, ground rod, ground wire, grounding bushings, and all hardware required to complete the installation shall be included in the cost of signal support foundation.

The cost of the pedestal metal base, pedestal pole, pole cap when necessary, anchor bolts, and all hardware required to complete the installation shall be included in the cost of signal pedestal.

The cost of weatherhead, 1 in. (25 mm) conduit riser, entrance switch, 1 ~~in.~~ to 2 in. (25 ~~mm~~ to 50 mm) conduit reducer, ground rod, ground wire, and all hardware required to complete the installation, including the meter base when required and supplied by the utility company shall be included in the cost of signal service.

The cost of the detector unit, lead-in cable, and all work necessary for proper installation shall be included in the cost of magnetometer detector or microloop detector probe. *The cost of all hardware and work required to provide and install signal cable*

from microloop detector probe, including extra-low voltage (home-run), from the handhole adjacent to the detector probe to the controller cabinet shall be included in the cost of signal cable.

The cost of the slot cut on the pavement, ~~sash cord~~, backer rod, loop sealant, and all testing in accordance with 805.09 shall be included in the cost of saw cut for roadway loop and sealant.

The cost of signal cable from preformed pave-over loops to handholes, detector housings or from loop to loop shall be included in the cost of the preformed pave-over loop.

The cost of all work and hardware required to properly install overhead or underground signal cable as shown on the plans or as directed shall be included in the cost of signal cable and signal interconnect cable.

~~The cost of the independent shelf mount unit or card rack unit, and power module shall be included in the cost of loop detector delay amplifier.~~

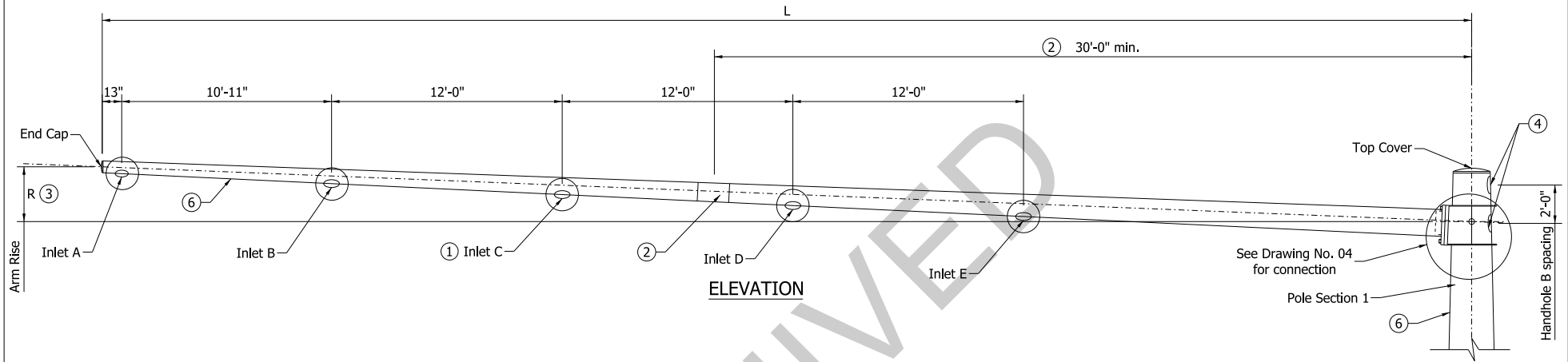
The cost of concrete reinforcing pipe, ring and cover eye bolts, hardware, handhole bottom, and aggregate under the handhole bottom as shown on the plans shall be included in the cost of handhole, signal.

The cost of aluminum casting, enclosure concrete, ~~steel~~-conduit and elbow, and all hardware required to complete the installation shall be included in the cost of signal detector housing.

The cost of steel pole bands or straight eye bolts, span, catenary, and tether of wire rope cables, cable rings, type A support cable, wire rope clips, safety cable, thimble, service sleeve, and all hardware required to complete the installation as shown on the plans shall be included in the cost of span, catenary, and tether for signal, or span and catenary for flasher.

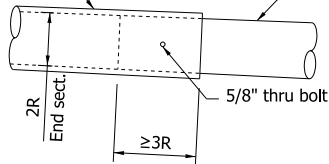
The cost to repair or replace damaged or lost salvageable traffic signal equipment shall be at the Contractor's expense.

The cost of excavation, backfill, final cleanup in accordance with 805.14, and necessary incidentals shall be included in the cost of the pay items in this section.

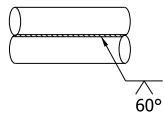


End section extension with wall thickness 3/16" and with drilled hole for 5/8" bolt

Base section with wall thickness 5/16" and field drilled hole for 5/8" Bolt



② OPTIONAL ARM SPLICE DETAIL



⑥ TYPICAL SEAM WELD

CANTILEVER SIGNAL ARM DATA

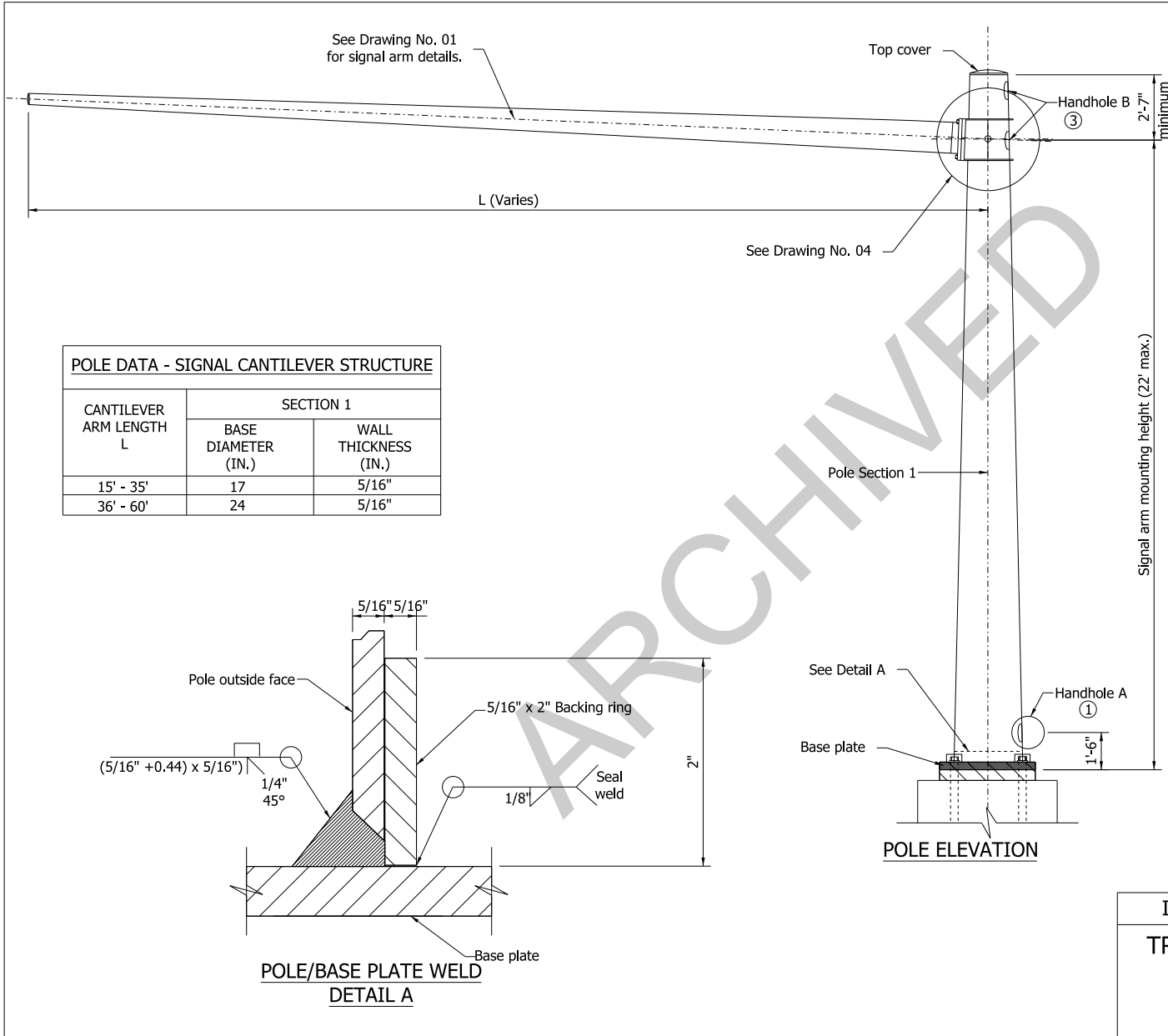
L (ft.)	ARM DIAMETER AT POLE	ARM WALL THICKNESS (in.)	R (in.)	CABLE INLETS
15	8"	5/16"	7 1/2"	A, B
20	10"	5/16"	10"	A, B
25	11"	5/16"	1'-0 1/2"	A, B
30	13"	5/16"	1'-3"	A, B
35	14"	5/16"	1'-5 1/2"	A, B, C
40	15"	5/16"	1'-8"	A, B, C
45	17"	5/16"	1'-10 1/2"	A, B, C
50	19"	5/16"	2'-1"	A, B, C, D
55	20"	5/16"	2'-3 1/2"	A, B, C, D
60	21"	5/16"	2'-6"	A, B, C, D, E

NOTES:

- ① Number of cable inlets depends on arm L (See Cantilever Signal Arm Data Table). The inlet diameter shall be 1 3/4" with rubber grommet (Typ.)
- ② Optional splice can be used for greater than 40' arm length. The splice shall be located a minimum of 30' from the pole. The end extension section of the arm shall have a wall thickness of 3/16" or greater. Field assembly shall achieve a snug tight joint (Min. overlap not less than 1.5 times the inside dimension of the end section).
- ③ Arm rise R is measured in the undeflected position without vertical loads on the arm.
- ④ See Page 5 for Handhole B details.
- 5. See Page 6 and 7 for placement of signal and signs for each arm length.
- ⑥ If seam welds are used, the weld location for the arms shall be along the bottom, and on the side of pole as shown.

INDIANA DEPARTMENT OF TRANSPORTATION

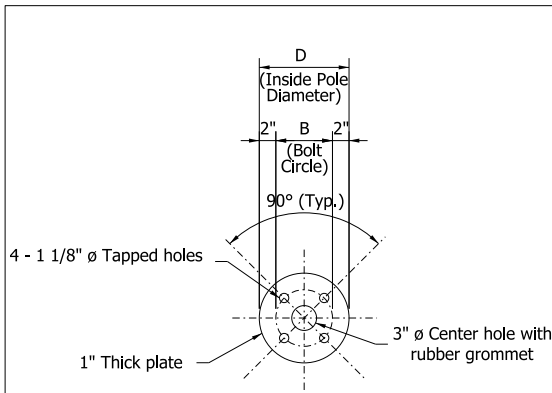
TRAFFIC SIGNAL CANTILEVER STRUCTURE
SIGNAL ARM DIMENSIONS & DETAILS



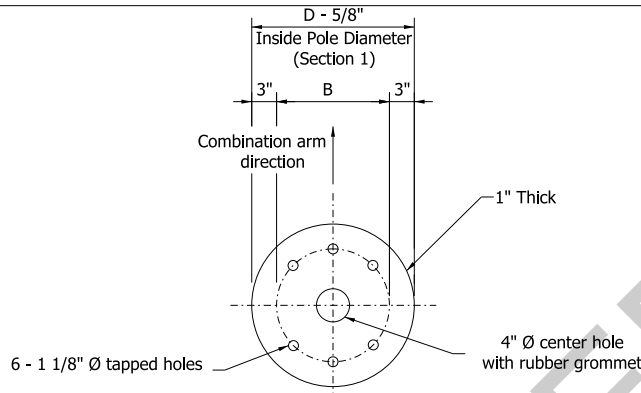
POLE DATA - SIGNAL CANTILEVER STRUCTURE		
CANTILEVER ARM LENGTH L	SECTION 1	
	BASE DIAMETER (IN.)	WALL THICKNESS (IN.)
15' - 35'	17	5/16"
36' - 60'	24	5/16"

- NOTES:**
- ① See Page No. 5 for Handhole A details.
 - ② See Standard Drawing No. E805-SGGR-01 to 03 for grounding details
 - ③ See Page No. 5 for Handhole B details.

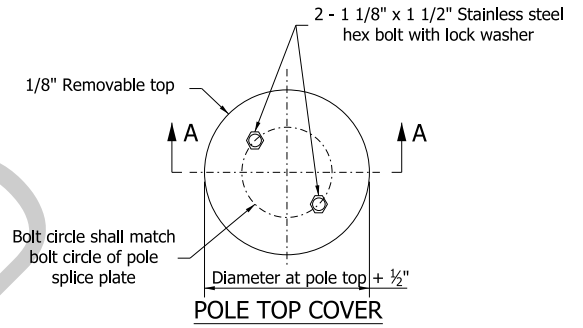
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 POLE DIMENSIONS AND DETAILS
 ELEVATION



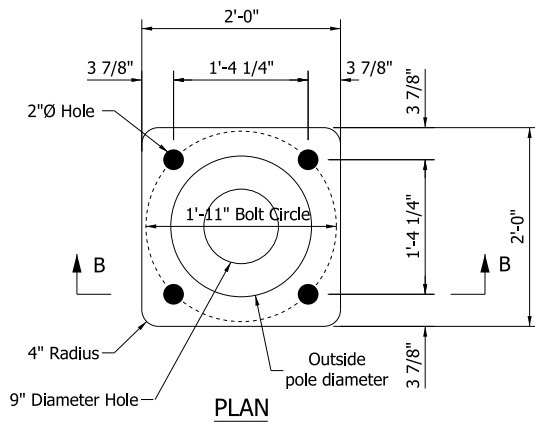
① **BOTTOM SPLICE PLATE**
(For 35' Cantilever Arm Lengths or Less)



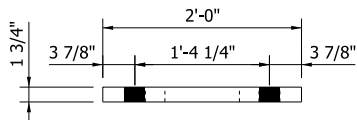
① **BOTTOM SPLICE PLATE**
(For Cantilever Arm Lengths Greater Than 35' to 60')



POLE TOP COVER

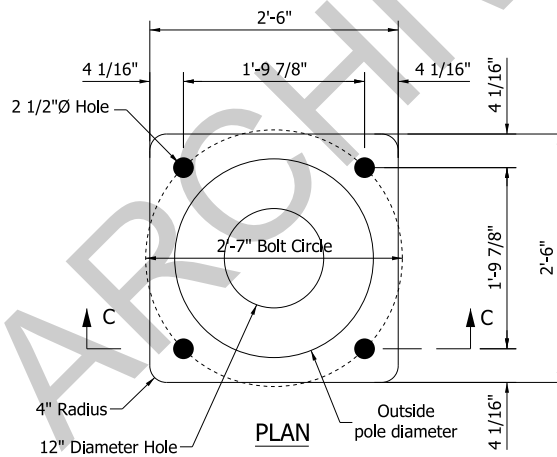


PLAN

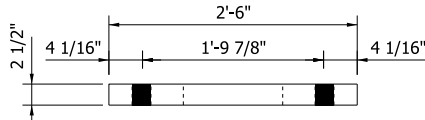


SECTION B-B

BASE PLATE A

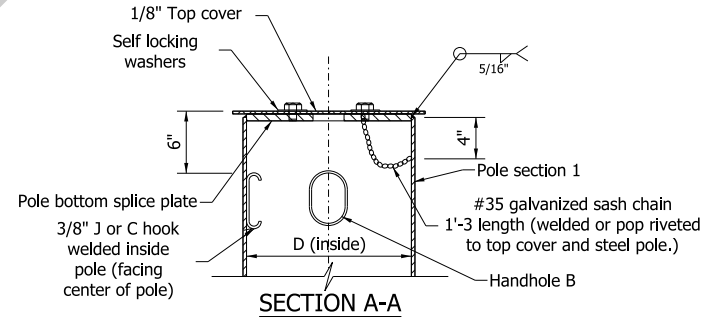


PLAN



SECTION C-C

BASE PLATE B

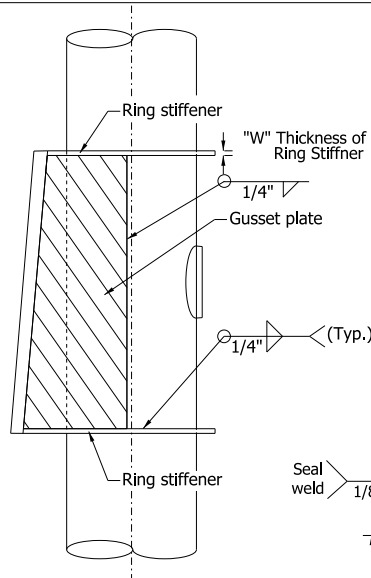


SECTION A-A

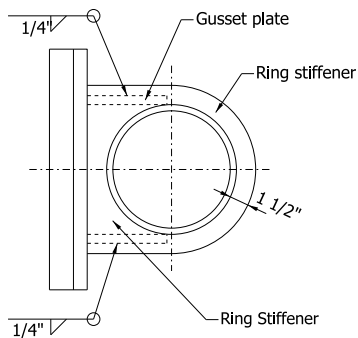
NOTES:

- ① See Page No. 11 and 12 for bottom splice plate orientation with combination arm.
- 2 Bolt circle shall allow clearance for the plate washer. Cutting or trimming the washer will not be allowed.

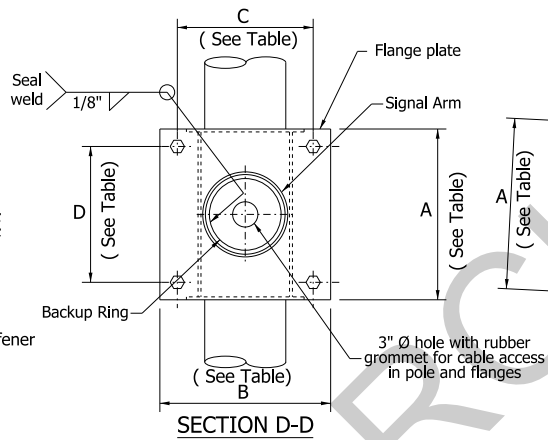
INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
BASE PLATE , BOTTOM SPLICE PLATE DETAILS



ELEVATION OF GUSSET PLATE

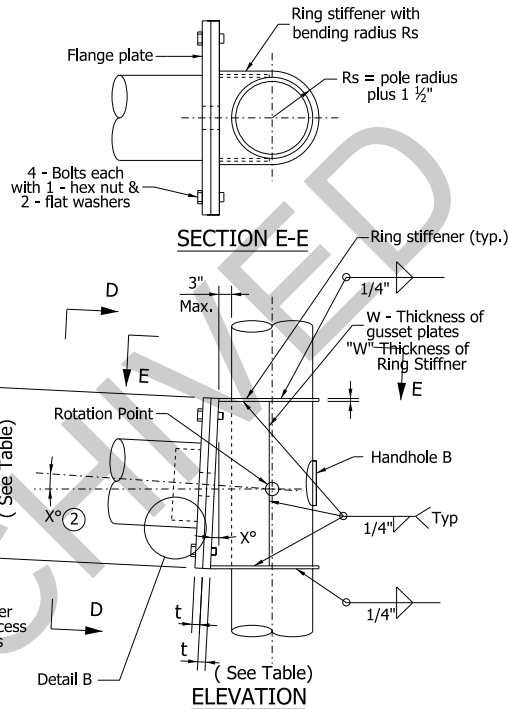


TOP OF GUSSET PLATE



SECTION D-D

SIGNAL ARM CONNECTION DETAIL

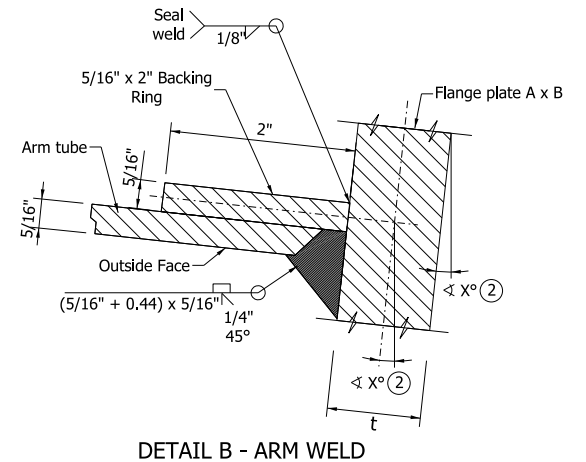


SECTION E-E

ELEVATION

NOTES:

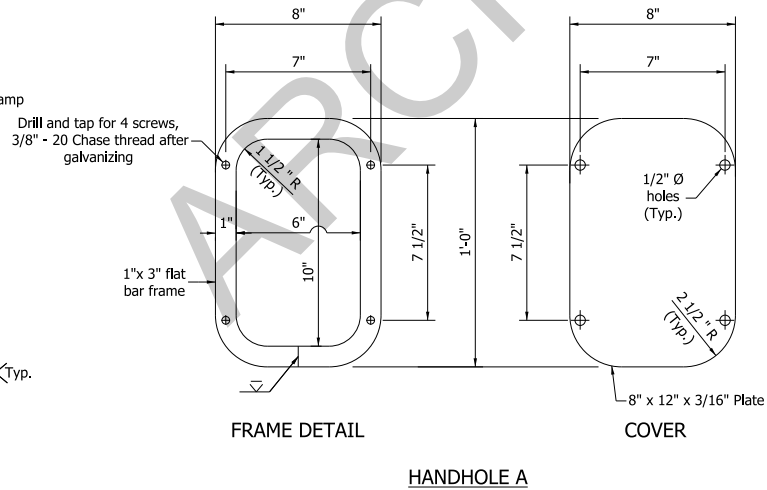
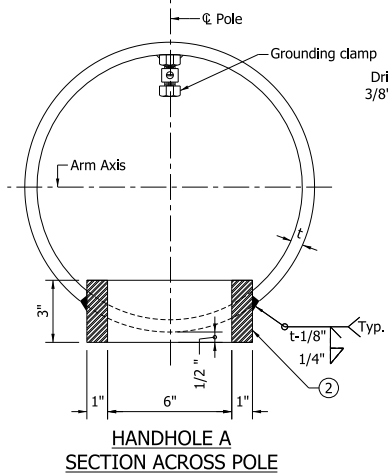
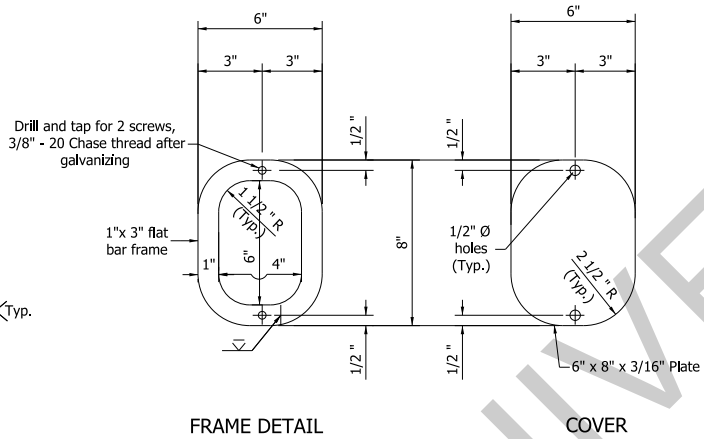
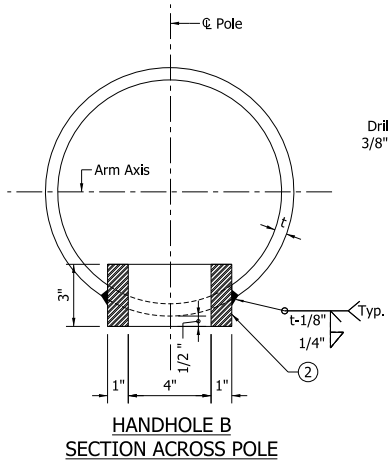
1. See Page No. 5 for Handhole B details.
- ② The required signal arm rise shall be built into the gusset plate at the angle X. The angle X is described as $\arctan R/L$, where R is the arm rise and L is the arm length. Both R and L vary and are listed in the Cantilever Signal Arm Data table on Page No. 1.



DETAIL B - ARM WELD

TABLE OF PLATES AND BOLTS FOR SIGNAL CANTILEVER ARM					
ARM LENGTH	FLANGE PLATE A x B	BOLT PATTERN C x D	RING STIFFNER GUSSET PLATE w	FLANGE PLATE THICKNESS t	BOLT
15' TO 35'	22" X 22"	17 1/2" X 17 1/2"	3/8"	1 1/2"	1 1/8" - 7 UNC x 4 1/4" LONG
36' TO 60'	33" X 33"	27 1/2" X 27 1/2"	1/2"	1 3/4"	1 1/2" - 6 UNC x 6 1/4" LONG

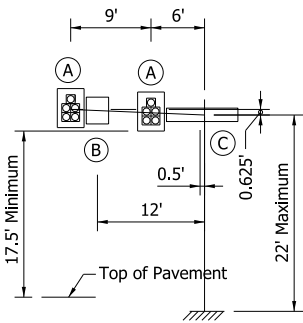
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 SIGNAL ARM CONNECTION DETAILS



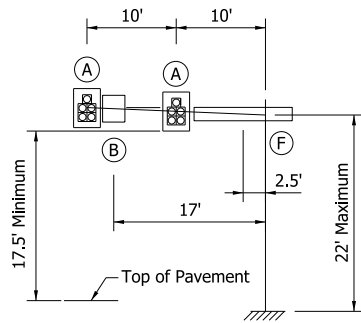
NOTES:

- 1 Handhole A shall be used at the base of the pole. Handhole B shall be used at all other locations.
- ② In lieu of fabricated handhole frame as shown, frame may be cut from 3" plate (rolling direction vertical).
- 3 See Page No. 2 for handhole locations.

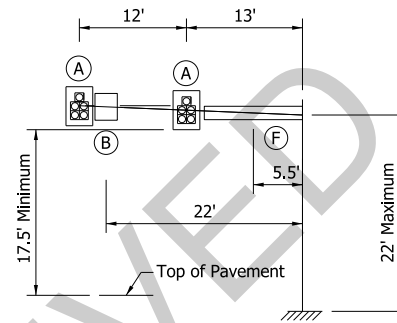
INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
HANDHOLE DETAILS



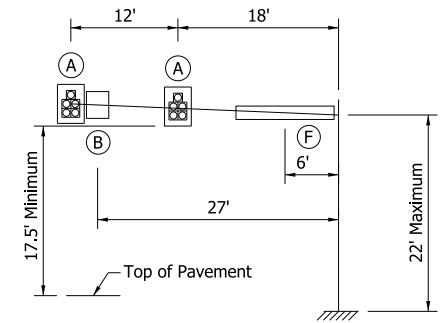
15' ARM



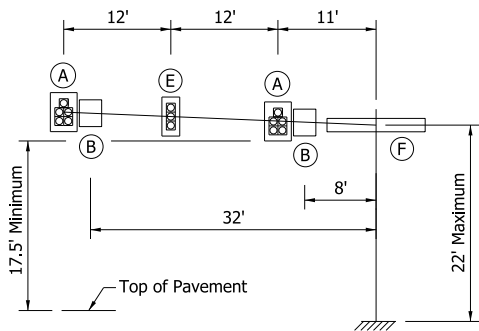
20' ARM



25' ARM



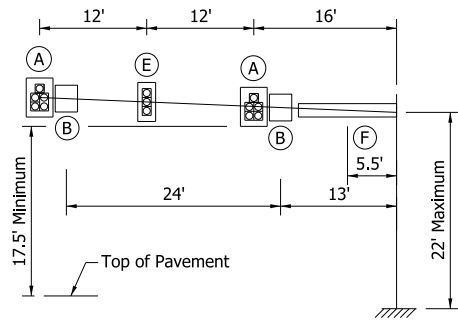
30' ARM



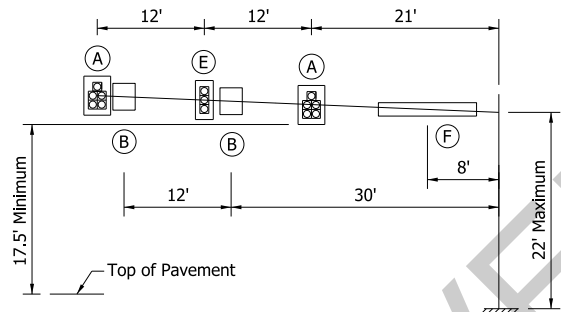
35' ARM

LEGEND	
Device	Description
(A)	12" - 5 Section Signal Head With Backplates
(B)	36" x 30" Regulatory Sign
(C)	18" x 96" Street Name Sign
(E)	12" - 3 Section Signal Head With Backplates
(F)	18" x 132" Street Name Sign

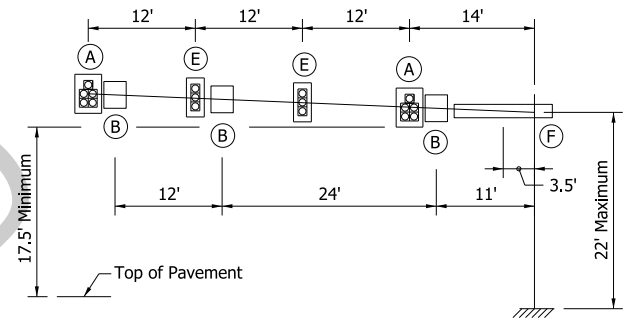
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 PLACEMENT OF SIGNALS AND SIGNS
 LOADING FOR ARMS 35' OR LESS



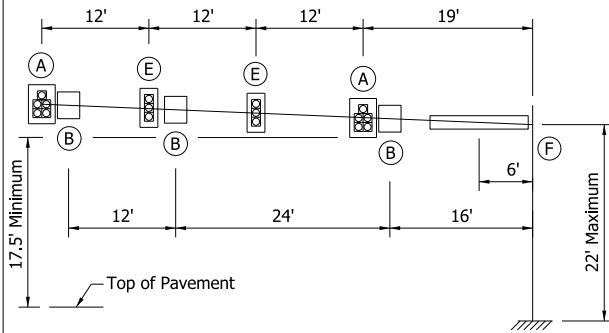
40' ARM



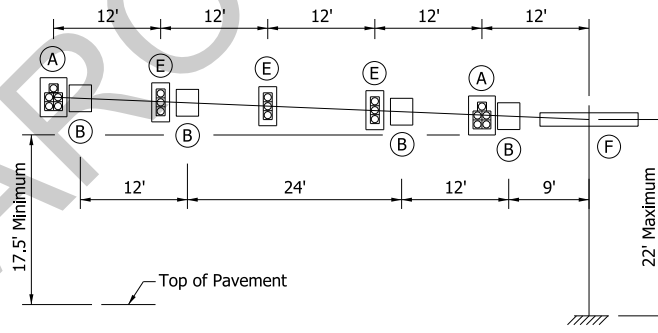
45' ARM



50' ARM



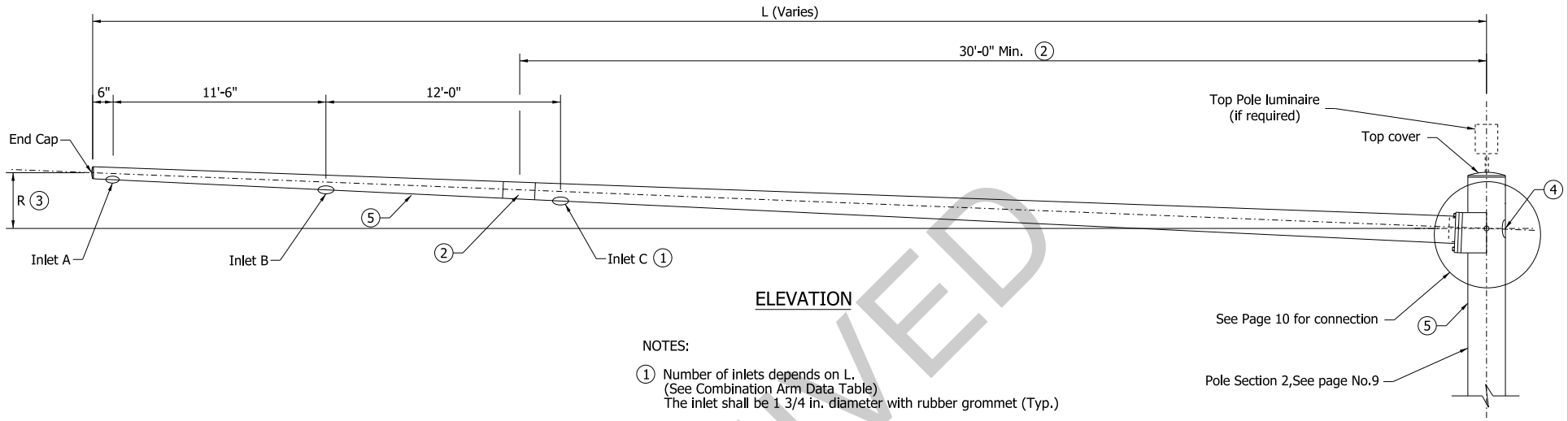
55' ARM



60' ARM

NOTE:
See Page No. 6 for Legend.

INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
PLACEMENT OF SIGNALS AND SIGNS
LOADING FOR ARMS > 35' TO 60'



ELEVATION

NOTES:

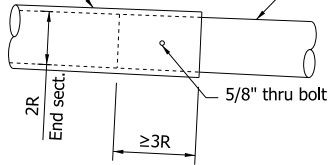
- ① Number of inlets depends on L. (See Combination Arm Data Table) The inlet shall be 1 3/4 in. diameter with rubber grommet (Typ.)
- ② Optional splice can be used for arm length greater than 40'. The splice shall be located a minimum of 30' from the pole. The end extension section of the arm shall have a wall thickness of 1/8" or greater. Field assembly shall achieve a snug tight joint (Min. overlap not less than 1.5 times the inside dimension of the end section).
- ③ Measured in deflected position after cameras are in place.
- ④ See Page No. 5 for Handhole B details.
- ⑤ If seam welds are used, the weld location for the arms shall be along the bottom, and on the side of the pole as shown.

VERTICAL CLEARANCE CRITERIA

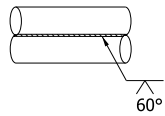
Maintain 40'-0" minimum clearances from top of pavement to the camera lens.

End section extension with wall thickness 1/8" and with drilled hole for 5/8" bolt

Base section with wall thickness 5/16" and field drilled hole for 5/8" Bolt



② **OPTIONAL ARM SPLICE DETAIL**



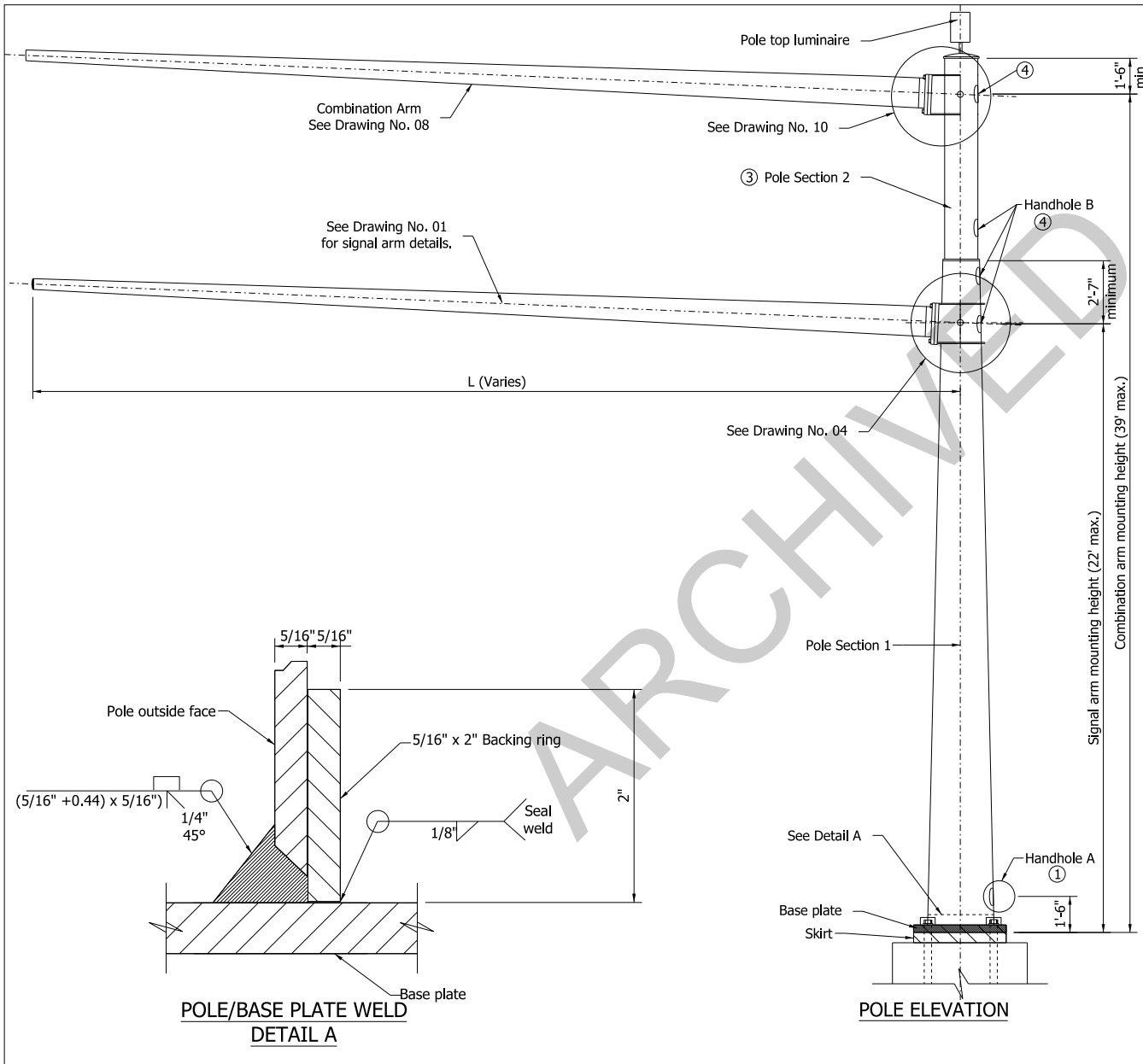
⑤ **TYPICAL SEAM WELD**

COMBINATION ARM DATA

L (Ft.)	ARM DIAMETER AT POLE	ARM THICKNESS	R ③	CABLE INLETS ①
15'	5.5"	1/8"	7 1/2"	A
20'	5.5"	1/8"	10"	A
25'	7.0"	1/8"	1'-0 1/2"	A
30'	8.0"	1/8"	1'-3"	A, B
35'	8.0"	1/8"	1'-5 1/2"	A, B
40'	9.0"	1/8"	1'-8"	A, B, C
45'	10.0"	1/8"	1'-10 1/2"	A, B, C
50'	11.0"	1/8"	2'-1"	A, B, C
55'	11.0"	1/8"	2'-3 1/2"	A, B, C
60'	12.0"	1/8"	2'-6"	A, B, C

INDIANA DEPARTMENT OF TRANSPORTATION

TRAFFIC SIGNAL CANTILEVER STRUCTURE
COMBINATION ARM DIMENSIONS & DETAILS

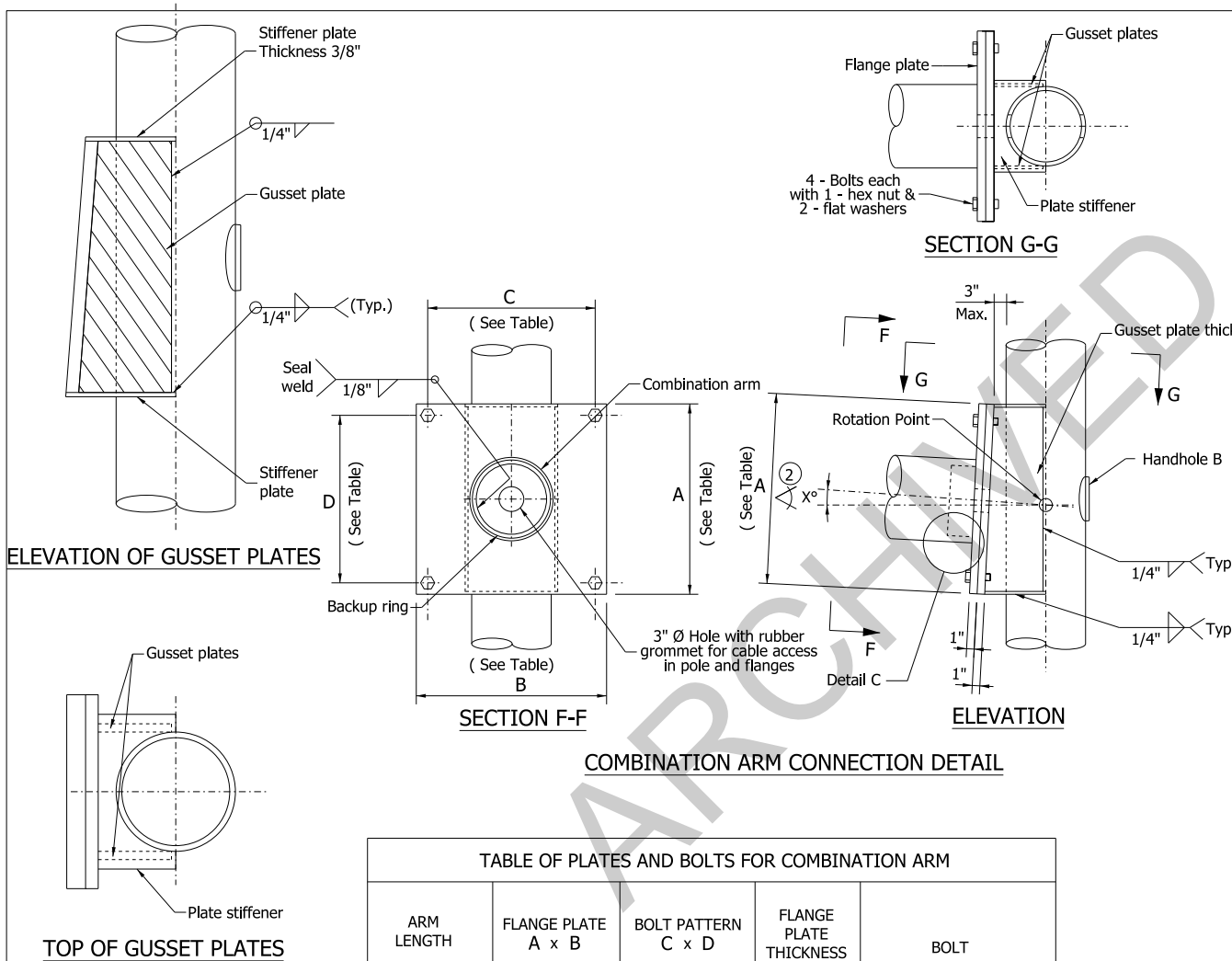


NOTES:

- ① See Page No. 5 for Handhole A details.
- 2 See Standard Drawings No. E805-SGGR-01 to 03 for grounding details.
- ③ Base diameter of Pole Section 2 shall be equal to top diameter of Pole Section 1.
- ④ See Page No.5 for Handhole B details.

POLE DATA - SIGNAL CANTILEVER STRUCTURE				
CANTILEVER ARM LENGTH L	SECTION 1		SECTION 2 COMBINATION	
	BASE DIAMETER (IN.)	WALL THICKNESS (IN.)	BASE DIAMETER (IN.)	WALL THICKNESS (IN.)
15' - 35'	17	5/16"	See Note ③	1/8"
36' - 60'	24	5/16"	See Note ③	1/8"

INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 COMBINATION POLE DIMENSIONS AND DETAILS
 ELEVATION



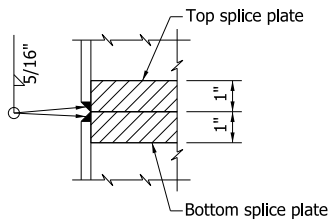
NOTES:

- 1 See Page No. 5 for Handhole details.
- 2 The required combination arm rise shall be built into the gusset plate at the angle X. The angle X is described as arc tan R/L, where R is the combination arm rise and L is the arm length. Both R and L vary and are listed in the Cantilever Signal Arm Data table on page No. 1.

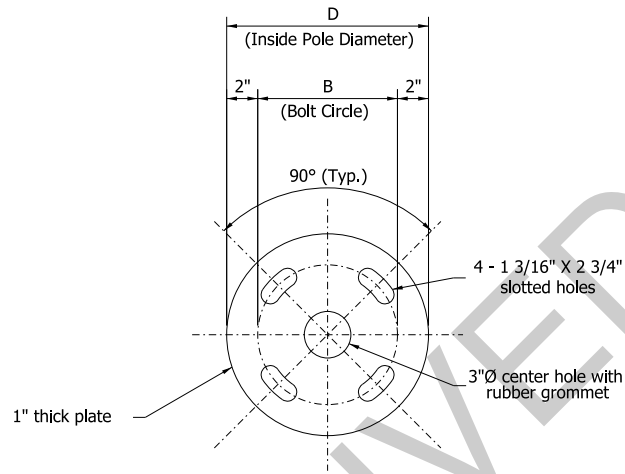
TABLE OF PLATES AND BOLTS FOR COMBINATION ARM

ARM LENGTH	FLANGE PLATE A x B	BOLT PATTERN C x D	FLANGE PLATE THICKNESS	BOLT
15' TO 35'	20" x 20"	17" x 17"	1"	7/8" - 9 UNC x 3.5" LONG
36' TO 60'	25" x 25"	22" x 22"	1"	7/8" - 9 UNC x 3.5" LONG

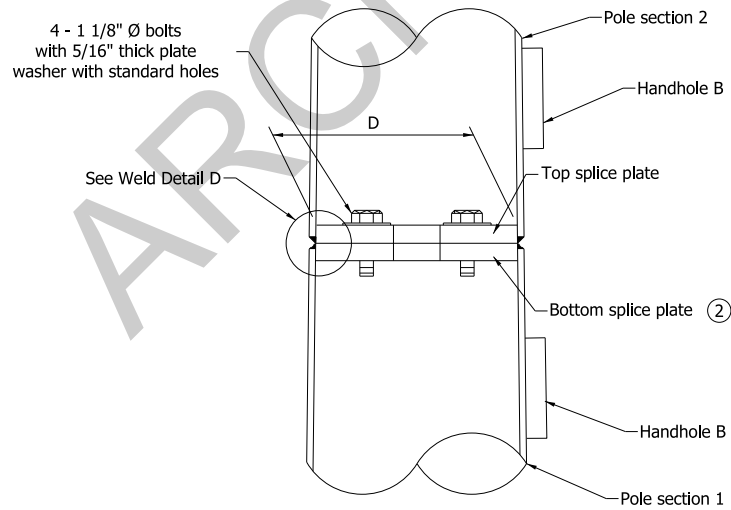
INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
COMBINATION ARM CONNECTION DETAILS



WELD DETAIL D



TOP SPLICE PLATE

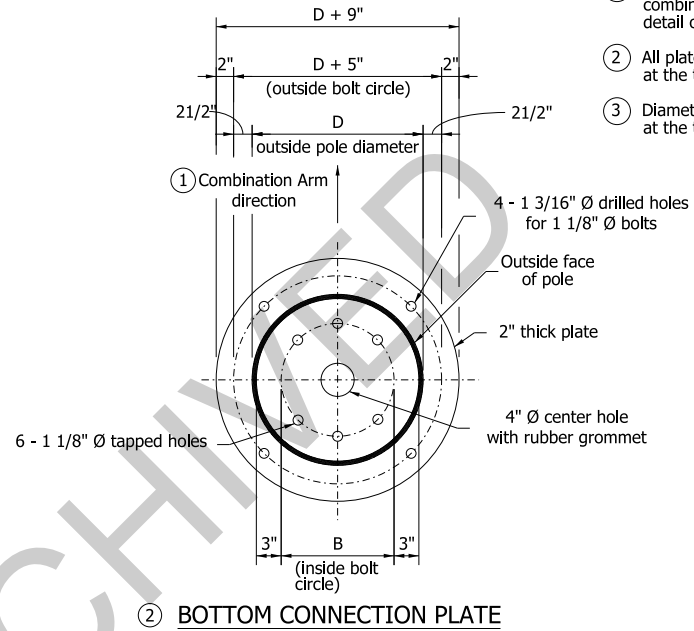
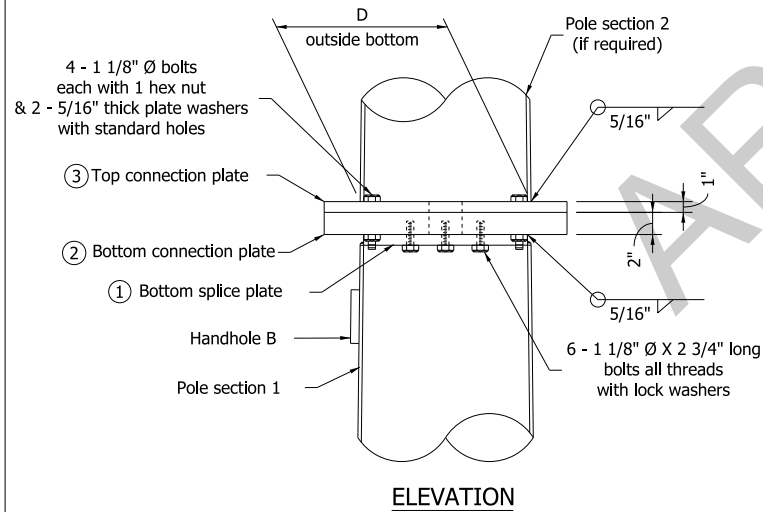
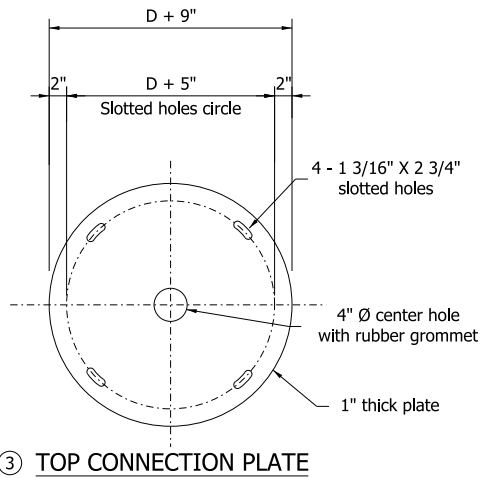


ELEVATION

NOTES:

- 1 Diameter at the bottom of Pole section 2 shall match the diameter at the top of Pole section 1.
- ② See page No.3 for bottom splice plate details.

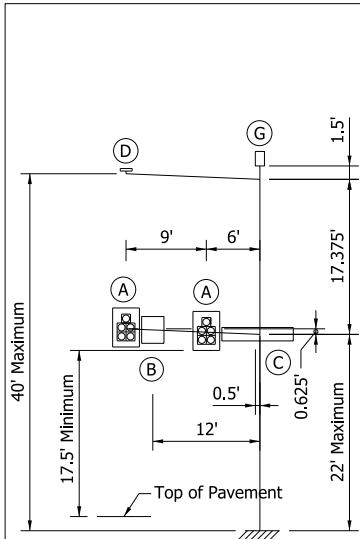
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 COMBINATION POLE SPLICE DETAILS
 FOR ARMS 35' OR LESS



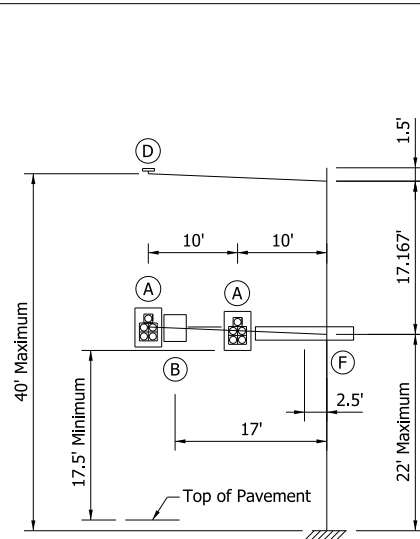
NOTES:

- ① Orient bottom splice and bottom connection plates with combination arm as shown on the bottom splice plate detail on Page No. 3.
- ② All plate dimensions shall be based upon the outside diameter D at the top of pole section 1.
- ③ Diameter at bottom of pole section 2 shall match the diameter at the top of pole section 1.

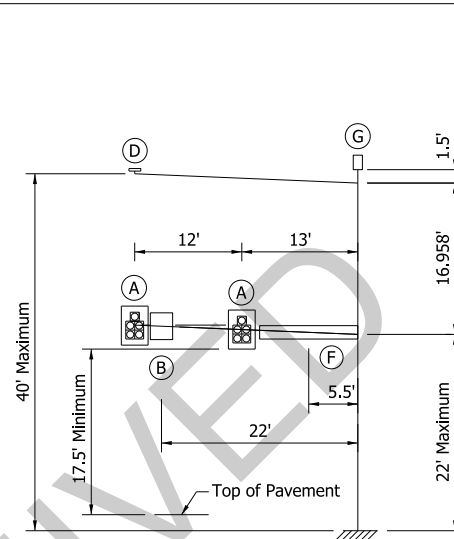
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 COMBINATION POLE SPLICE DETAILS
 FOR ARMS > 35' TO 60'



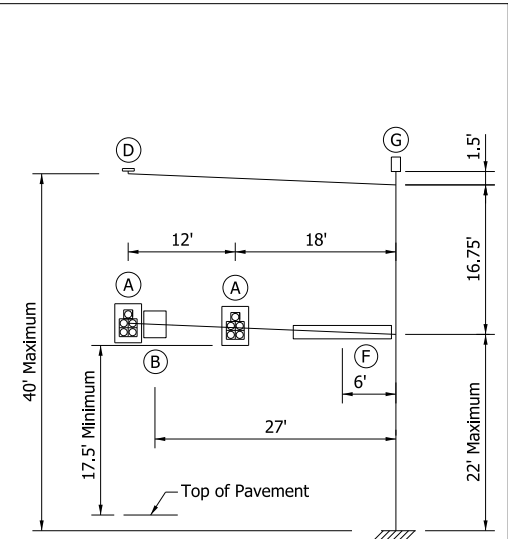
15' ARM



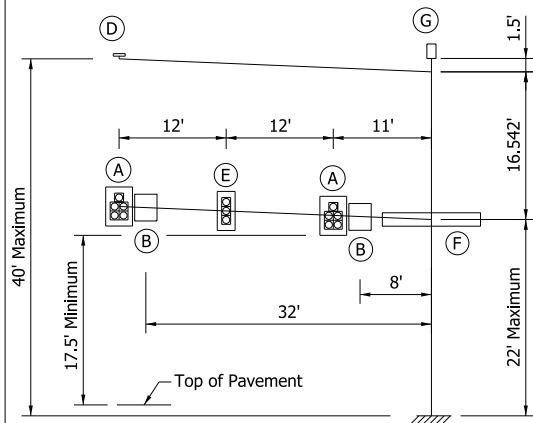
20' ARM



25' ARM



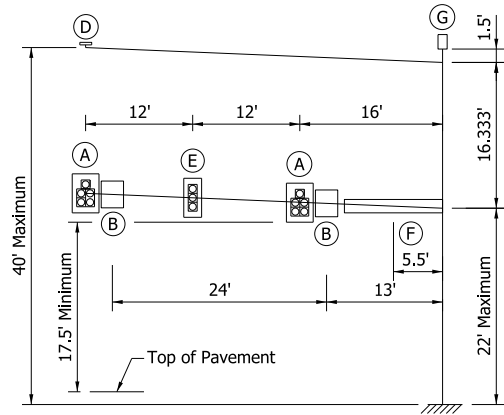
30' ARM



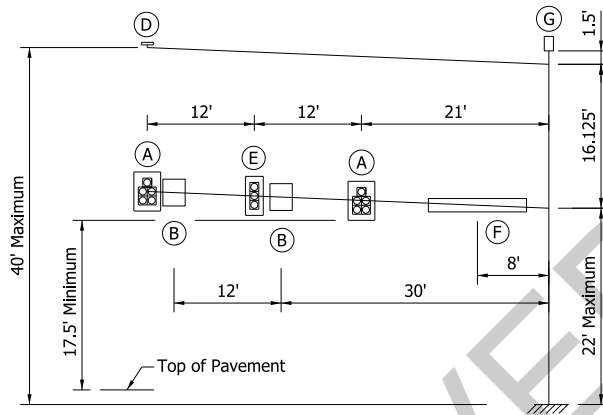
35' ARM

LEGEND	
Device	Description
(A)	12" - 5 Section Signal Head With Backplates
(B)	36" x 30" Regulatory Sign
(C)	18" x 96" Street Name Sign
(D)	1 - Mounted Camera
(E)	12" - 3 Section Signal Head With Backplates
(F)	18" x 132" Street Name Sign
(G)	Top Pole Luminaire

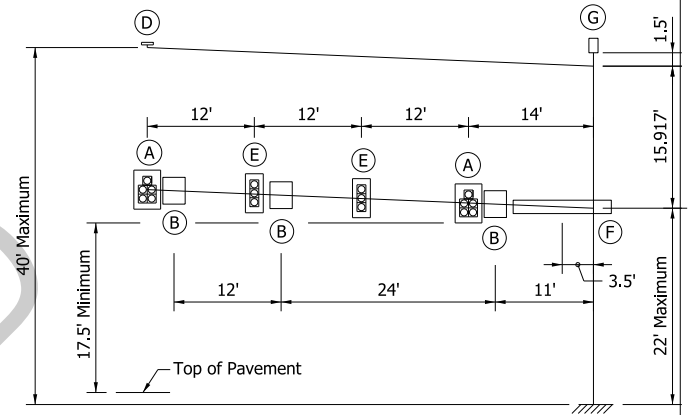
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 COMBINATION ARM LOADING
 FOR 35' ARM OR LESS



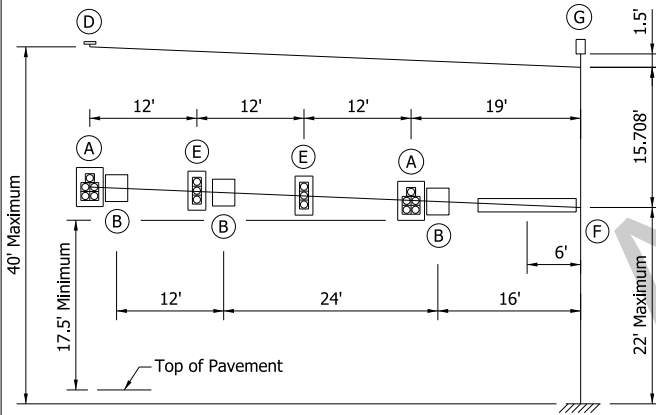
40' ARM



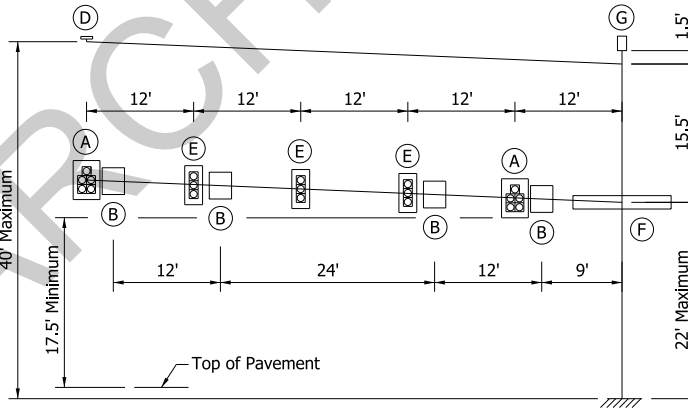
45' ARM



50' ARM



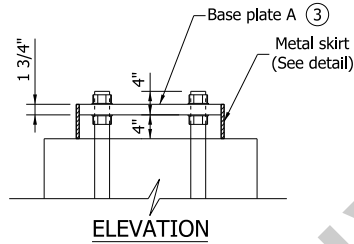
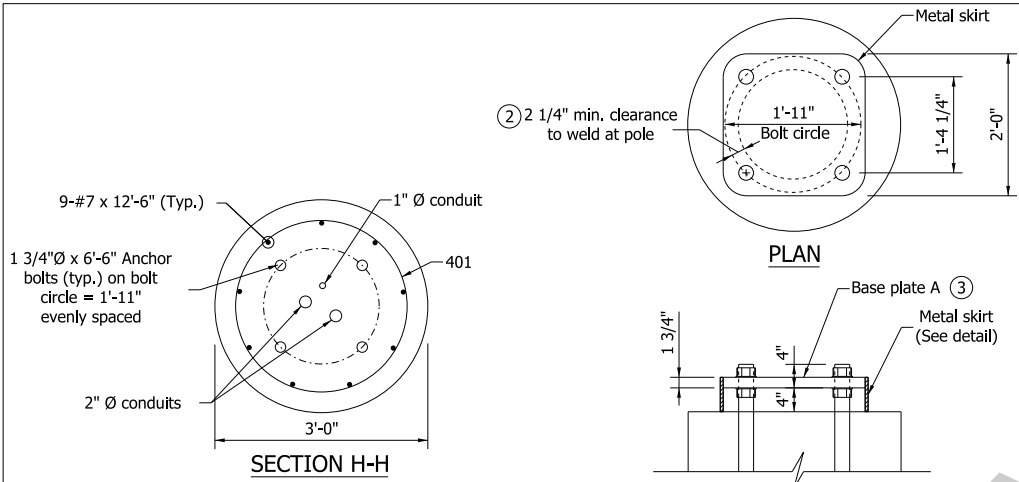
55' ARM



60' ARM

NOTE:
See Page No. 13 for Legend.

INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
COMBINATION ARM LOADING
FOR ARMS > 35' TO 60'

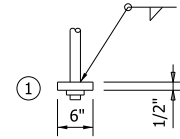
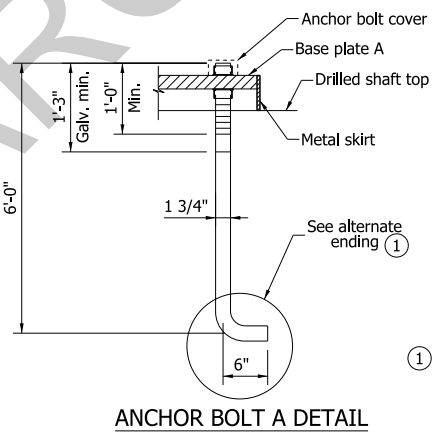
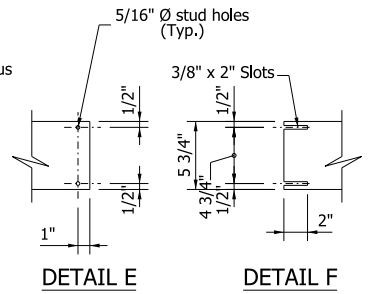
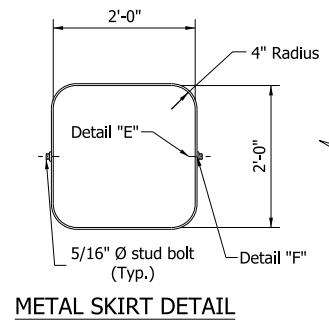
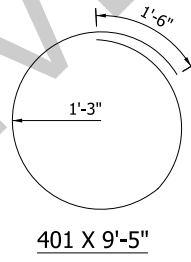
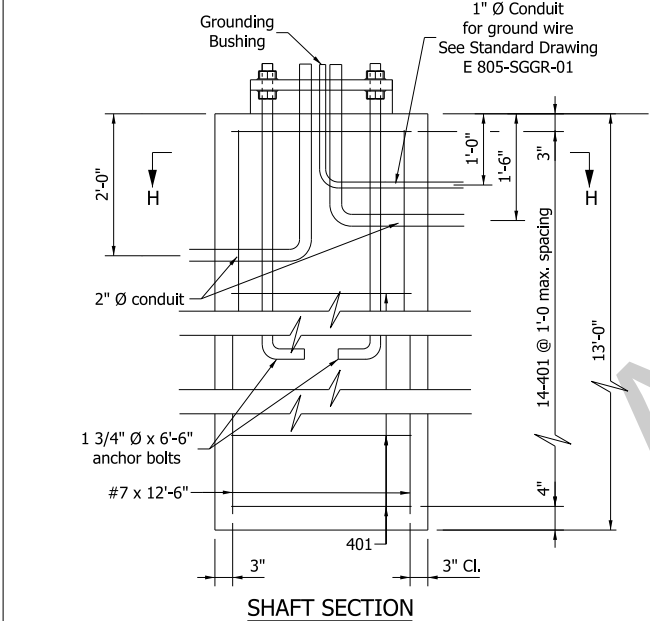


NOTES:

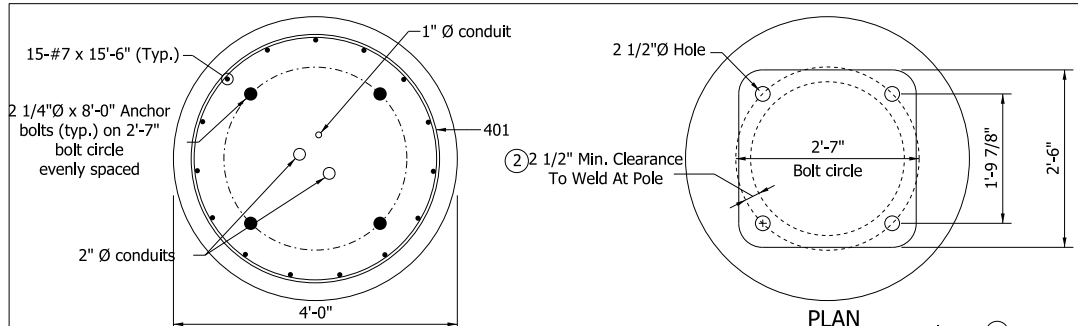
- ① Alternate 6" x 6" x 1/2" square washer with hex nut welded to lower end may be substituted for bent anchor bolt.
- ② Bolt circle, b, shall allow clearance for the plate washer. Cutting or trimming the washer will not be allowed.
- ③ See Page No. 3 for base plate A details.

**BILL OF MATERIALS
 DRILLED SHAFT
 TYPE A**

REINFORCING BARS			
SIZE OR MARK	NUMBER OF BARS	LENGTH (ft.)	WEIGHT (lbs.)
#7	9	12'-6"	
TOTAL #7			230
401	14	9'-5"	
TOTAL #4			88
TOTAL REINFORCING BARS			318
CONCRETE			
CONCRETE, CLASS A			3.4 CYS



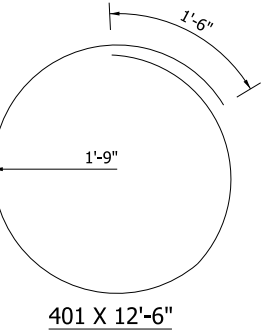
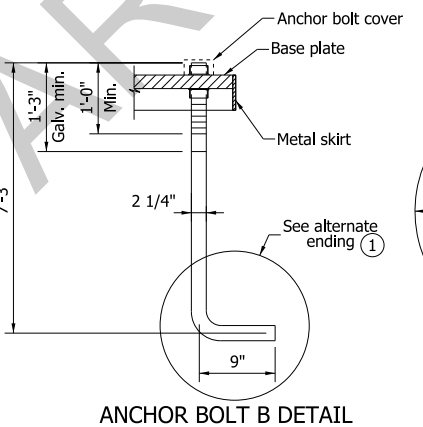
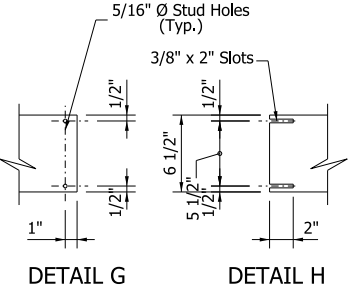
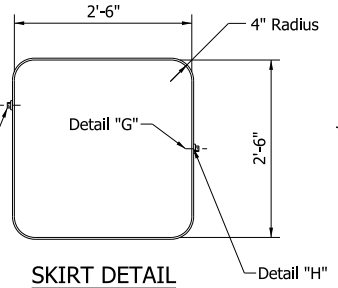
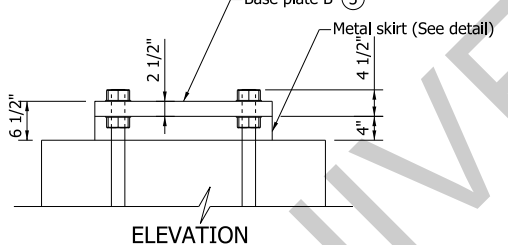
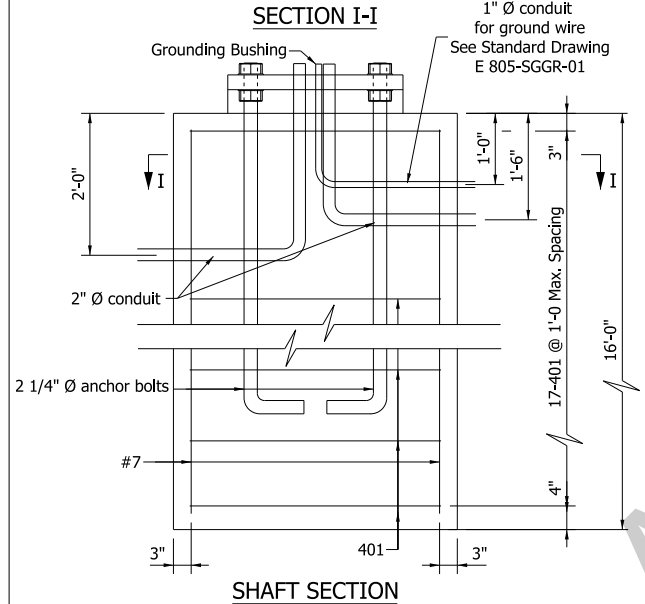
INDIANA DEPARTMENT OF TRANSPORTATION
 TRAFFIC SIGNAL CANTILEVER STRUCTURE
 DRILLED SHAFT FOUNDATION
 FOR ARMS 35' OR LESS
 TYPE A



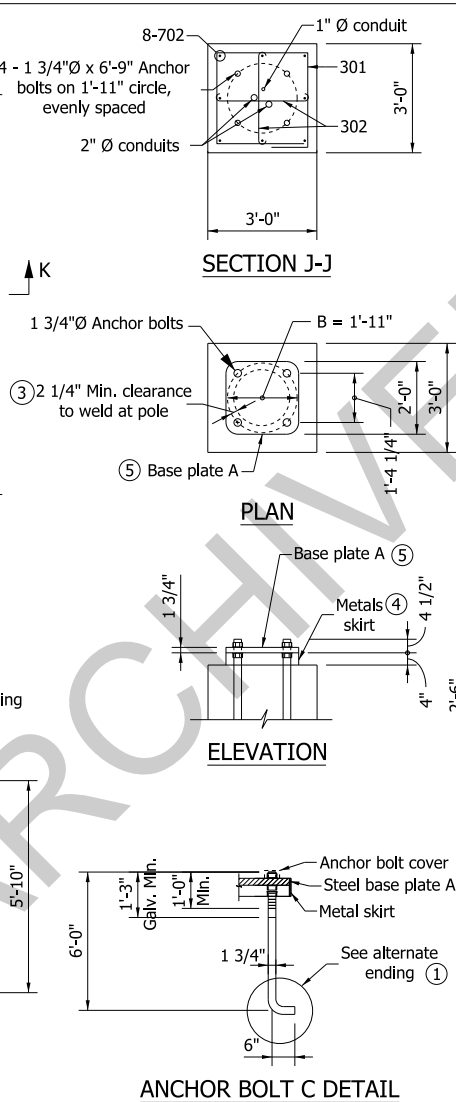
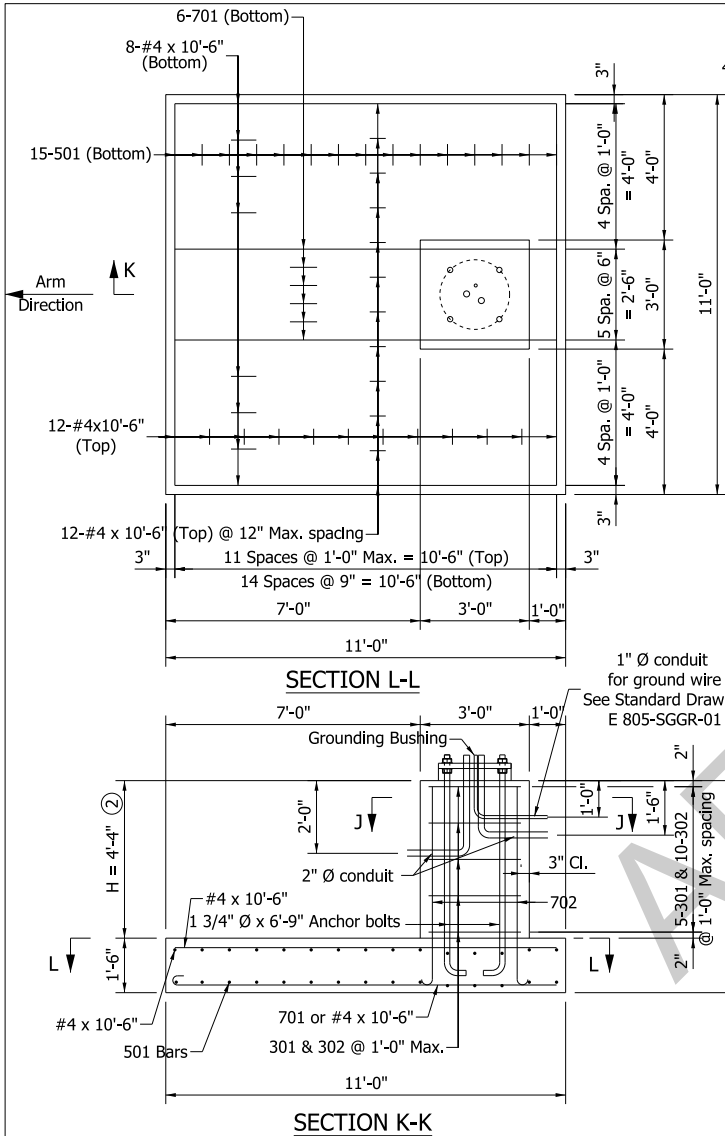
NOTES:

- ① Alternate 8" x 8" x 1/2" square plate tapped and welded to the anchor bolt may be substituted for bent anchor bolt.
- ② Bolt circle, b, shall allow clearance for the plate washer. Cutting or trimming the washer will not be allowed.
- ③ See Page No. 3 for base plate B details.

BILL OF MATERIALS DRILLED SHAFT TYPE B			
REINFORCING BARS			
SIZE OR MARK	NUMBER OF BARS	LENGTH (ft.)	WEIGHT (lbs.)
#7	15	15'-6"	
TOTAL #7			475
401	17	12'-6"	
TOTAL #4			142
TOTAL REINFORCING BARS			617
CONCRETE			
CONCRETE, CLASS A			7.5 CYS

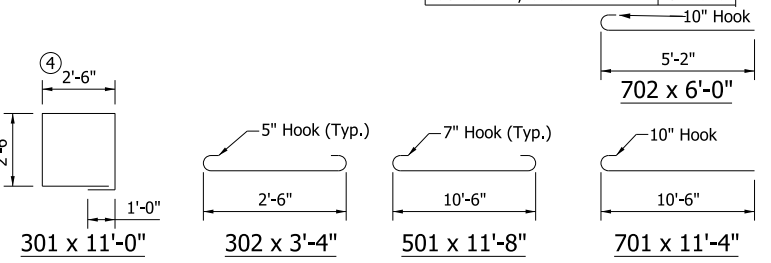


INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
DRILLED SHAFT FOUNDATION FOR ARMS >35' TO 60'
TYPE B



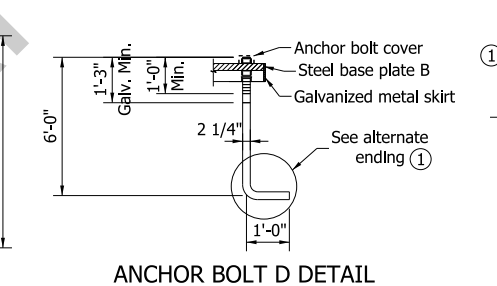
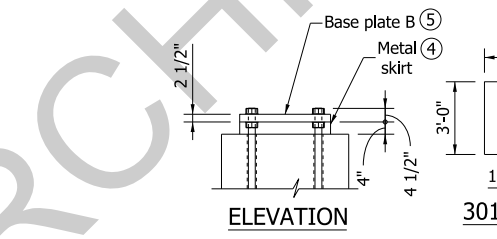
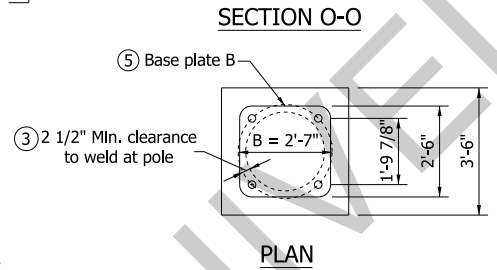
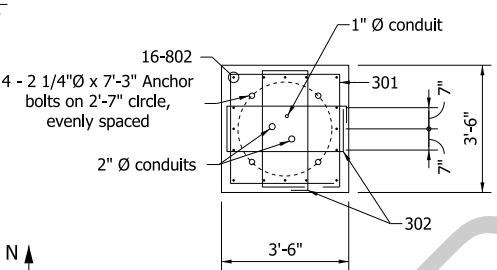
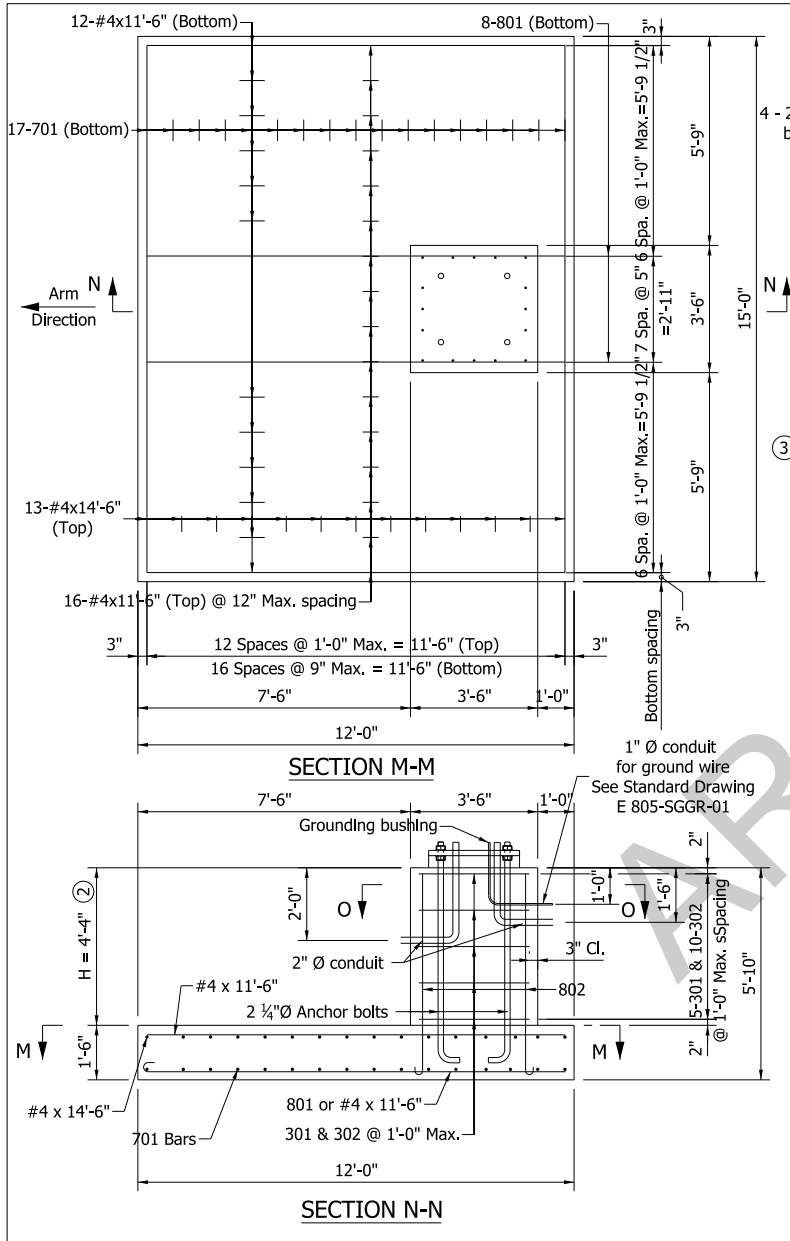
- NOTES:**
- 1 Alternate 6" x 6" x 1/2" square washer with hex nut welded to lower end may be substituted for the bend in the anchor bolt.
 - 2 Minimum H required is 4 ft. soil cover over the entire footing area.
 - 3 Bolt circle, B, shall allow clearance for the plate washer. Cutting or trimming the washer will not be allowed.
 - 4 See Page No. 15 for metal skirt details.
 - 5 See Page No. 3 for base plate A details.

BILL OF MATERIALS SPREAD FOOTING TYPE C			
REINFORCING BARS			
SIZE OR MARK	NUMBER OF BARS	LENGTH (ft.)	WEIGHT (lbs.)
701	6	11'-4"	
702	8	6'-0"	
TOTAL #7			237
501	15	11'-8"	
TOTAL #5			183
#4	32	10'-6"	
TOTAL #4			224
301	5	11'-0"	
302	10	3'-4"	
TOTAL #3			33
TOTAL REINFORCING BARS			677
CONCRETE			
CONCRETE, CLASS A			8.2 CYS



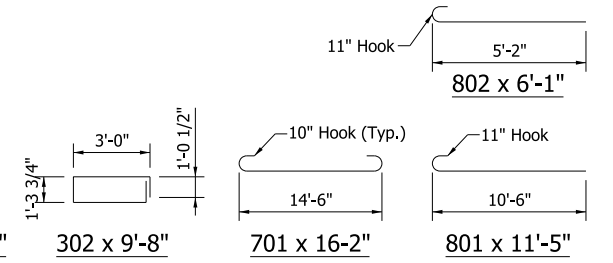
INDIANA DEPARTMENT OF TRANSPORTATION

TRAFFIC SIGNAL CANTILEVER STRUCTURE
SPREAD FOUNDATION FOR ARMS 35' OR LESS
TYPE C



- NOTES:**
- ① Alternate 8" x 8" x 1/2" square plate tapped and welded to anchor bolt may be substituted for the bent anchor bolt.
 - ② Minimum H required is 4 ft. soil cover over the entire footing area.
 - ③ Bolt circle, B, shall allow clearance for the plate washer. Cutting or trimming the washer will not be allowed.
 - ④ See Page No. 16 for metal skirt details.
 - ⑤ See Page No. 3 for base plate B details.

BILL OF MATERIALS SPREAD FOOTING TYPE D			
REINFORCING BARS			
SIZE OR MARK	NUMBER OF BARS	LENGTH (ft.)	WEIGHT (lbs.)
801	8	11'-5"	
802	16	6'-1"	
TOTAL #8			504
701	17	16'-2"	
TOTAL #7			562
#4	13	14'-6"	
#4	28	11'-6"	
TOTAL #4			341
301	5	13'-0"	
302	10	9'-8"	
TOTAL #3			61
TOTAL REINFORCING BARS			1468
CONCRETE			
CONCRETE, CLASS A			12.0 CYS



INDIANA DEPARTMENT OF TRANSPORTATION
TRAFFIC SIGNAL CANTILEVER STRUCTURE
SPREAD FOUNDATION FOR ARMS > 35' TO 60'
TYPE D

922-T-168 TRAFFIC SIGNAL MATERIALS AND EQUIPMENT

(Revised 09-15-11)

The Standard Specifications are revised as follows:

SECTION 922, DELETE LINES 1 THROUGH 1850.

SECTION 922, AFTER LINE 1850, INSERT AS FOLLOWS:

SECTION 922 – TRAFFIC SIGNAL MATERIALS

922.01 Description

All traffic signal materials and equipment shall be in accordance with the NEMA TS2-2003 Standards Publication, and be compatible with the Department's current inventory of signal equipment, unless specifically outlined in the following specification.

922.02 Traffic Signal Control Equipment

10 *Models shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment, unless otherwise specified.*

(a) Model Approval

20 *Each model of controller assembly, CA, and all major units, as defined in NEMA TS2-2.1.1, will be tested and evaluated by the Department's Logistical Support Center, and approved prior to use. The CA, as defined by NEMA TS2-1.1.7, as being a complete electrical unit, shall include major units operational in a TS2 environment. Major units of the CA are defined as controller unit, CU; malfunction management unit, MMU; bus interface unit, BIU; cabinet power supply; load switches; vehicle detector equipment;*

30 *cellular modems; radio modems, and flasher. The evaluation of a product will be considered when the Department receives the preliminary product evaluation submittal form. The Department will advise the manufacturer or vendor, of the date of delivery at which time a presentation of the product will be required accompanied by the product brochure, the operational manual containing procedures for all features incorporated in the CU's design, and the maintenance manual containing all schematics, pictorial parts layouts, components parts listings, and documented theory of operation. Certification in accordance with 922.02(d) shall also accompany the preliminary product evaluation form. If a product has TS2 communicative capabilities, then a data analysis interpretation offered in a decimal form expressing frames by an SDLC protocol analyzer shall accompany the initial documentation as well. When accuracy of documentation is validated, the evaluation period may commence. In addition, all computer system software applicable to a manufacturer's product shall work with the Department's current operating systems so that upgrades will not be needed to recognize the full potential of the product. Any product under evaluation that has an operational failure occurring during the bench test procedure will be rejected and returned to the submitter. The product will not be considered for future evaluation without a cover letter documenting failures encountered and changes to the design to correct the failures. A presentation by the manufacturer of the product in question and explanation of why the product failed will be required. Resubmittal of the original product will be expected for*

40 *testing, evaluation, and approval. Furthermore, 2 more rejections of a product submitted for evaluation will be cause to deny approval of that model permanently.*

Continued failures indicative of a trend, repeated random malfunctions, or NEMA non-compliance of an approved product shall be cause to remove that model from the Department's list of approved Traffic Signal and ITS Control Equipment. If the manufacturer makes any changes to an approved model of major unit and/or controller cabinet terminal/facilities to correct a non-NEMA compliant or safety issue, the Department is to be notified immediately. The manufacturer will be required to correct all existing equipment purchased by the Department either directly, by contract, or through agreement prior to the change being incorporated at the manufacturer's production level.

A design change to an approved model of a CA or any major unit will require a submittal of documented changes. At the discretion of the Department, resubmission of the model for testing, evaluation, and approval may be required. The permanent addition or removal of component parts or wires, printed circuit board modifications, or revisions to memory or processor software, are examples of items that are considered to be design changes.

60 **(b) Controller Assemblies or Major Units Furnished and Installed by the Contractor**

A CA, as defined by NEMA TS2-1.1.7, shall be provided by the Contractor and shall be built to the specifications of the intersection design.

Each CA shall be supplied with 3 documentation packets. The documentation shall be provided in both paper hard copy and electronically as specified for each document. Each packet shall consist of:

- 70 1. One complete set of wiring and schematic diagrams for all of the CA's panels, racks and wiring; the electronic document shall be Adobe (.pdf) and have a minimum of 1 indexed page for each paper sheet.
2. A parts list indicating contract number, vendor, category, manufacturer, model, serial number, software/firmware version as applicable, and inventory number of all major units incorporated in the CA; the electronic document shall be MS Excel (.xls) and the blank worksheet shall be obtained from the Department's Logistical Support Center.
- 80 3. An 11 by 17 in. intersection design plan; the electronic document shall be Adobe (.pdf).
4. A completed Department approved loop tagging table; the electronic document shall be MS Excel (.xls) and the blank worksheet shall be obtained from the Department's Logistical Support Center.
5. Packet number 2 shall also include a paper hard copy and an indexed and searchable electronic pdf format file of the instructional programming manual identical in nature to that approved for use

90 *during the evaluation of each product and shall include a TS2 type 2 to TS2 type 1 adapter harness.*

All electronic documents shall be saved to CD (compact disk, CD-R or CD-RW) in the specified format for each document. Each packet shall be labeled with the name of the intersection, the contract number, the commission number and the date of installation. Packet destinations shall be as per 805.08.

100 *A 60-day burn-in period of traffic control equipment shall be required prior to acceptance of the contract. The Contractor shall be responsible for all costs associated with vendor or manufacturer warranty service until acceptance of the contract, or acceptance of that portion of the contract where the traffic control equipment is installed.*

(c) Warranty

110 *A 5-year manufacturer's or vendor's warranty shall be provided for all major units operating in a TS2 environment. Light emitting diode, LED, signal indications shall have a 5-year manufacturer's or vendor's warranty. Video detection equipment shall have a 10-year manufacturer's or vendor's warranty period on processors, integrated camera/processor units, rack mount cards, hubs, minihubs and camera interface panels. CCD video cameras shall have a 5-year manufacturer's or vendor's warranty. Load switches and flashers shall have a 2-year manufacturer's or vendor's warranty. Warranty periods shall commence from the date of field placement of the device or on the date of signal turn-on as shown on the IC 636A form if purchased through a contracting agent.*

(d) Certification of NEMA TS2 Traffic Control Equipment

The following certifications shall be furnished.

1. Certification of a Production Run Model

120 *A certification representing each model of approved major unit of a CA shall be on file with the Department. A certification of a production run model for a CU will be valid for a maximum period of 5 years from the date of approval or unless a significant change is made in the CU. If a significant change is made, a new certification shall be submitted. A significant change shall be the addition or deletion of any function or feature in the control unit, or any other change as defined in 922.02(a) to the circuitry in the product.*

2. Certification of Environmental Testing

130 *A certification shall be furnished with each major unit approval request indicating it has been tested and is in accordance with the tests from NEMA TS2-2. The certification shall specify the model and serial number of the product being tested. A complete log of each test shall be provided to the Department and will be maintained by the Department. The log shall show which, if any, controller component failed during the test, when it failed, and what steps were taken to repair the controller. The log shall include the date of testing, name and title of person conducting the tests, a record of conditions throughout the tests, and a temperature and humidity verses time chart. The maximum report interval of any chart shall be 24 h. The chart shall be from a recording machine used to monitor the status of the environmental chamber during testing.*

(e) NEMA TS2 Fully Actuated Solid State Controller Unit, CU

140 The following requirements are the minimum for the design and operation of a 16 channel fully actuated solid state CU. The NEMA TS2 configuration will consist of 2 types of CU's, type A1 and type A2, as defined in NEMA TS2-3.2.

The CU shall be in accordance with NEMA TS2 Standards, all provisions contained herein, and the Department's specifications. Manufacturer specific enhancements are acceptable; however, no function or device shall preclude the interchangeability of a CU with another CU of like NEMA specification within a controller assembly.

150 **1. General Requirements**

The CU shall be microprocessor based and both versions shall contain a 3-port configuration and shall operate in the NEMA TS2 type A1 environment.

The CU shall include provisions for time-of-day programming. The CU shall be capable of a minimum of 50 programmed events and be in accordance with NEMA TS2-3.8.

160 A removable nonvolatile EEPROM module shall be utilized in each CU to maintain all programmed data. A real-time clock shall be battery-backed and active during a power outage so as to provide complete time keeping functions and leap year corrections. A switch or other means shall be provided to turn off or disconnect battery power during storage. This shall be accomplished without physical removal of the battery. Batteries within the CU shall be turned off or disconnected during storage and shipment.

Programming and maintenance manuals for approved CU's shall be identical in nature to that approved for use during the evaluation period of the CU. The Department shall be notified of any changes to the manuals.

170 Serial number and model numbers shall be permanently applied on or near the front of circuit boards of the CU and viewable without removing or disconnecting the board. Serial number and model number of the main frame shall be permanently applied externally on top or on the front panel.

2. CU Requirements

The requirements set forth herein refer to a type A1 and A2 CU. Where differences occur between types, it will be designated.

180 The CU shall have, as a minimum, the internal diagnostics defined by NEMA TS2-3.9.3.

The CU shall monitor and log the status of events as specified in NEMA TS2-3.9.3.1.5 in non-volatile memory and shall be selectable via program entry and be retrievable by the system computer via NEMA port 2 or 3. In addition, the CU shall have the ability to log an MMU fault as it occurs. A minimum of 16 entries shall be stored in

190 *non-volatile memory. When capacity is exceeded, the oldest entry will be replaced by the newest. Logged entries shall at minimum contain the date and time denoted in military style with minute resolution, description of the fault as it would appear on the MMU, and the status of each of the channel inputs at the time the fault occurred, clearly denoting the presence of activity on a channel.*

200 *The CU shall be capable of all inputs and outputs listed by controller type in NEMA TS2-3. Pedestrian timing shall be provided on all phases of a CU. Unless otherwise indicated on the plans, the CU, when delivered, shall be programmed to initialize in phase 2 and phase 6 green, however, the CU shall be keyboard programmable to permit initialization in any color and phase. Initialization shall occur after a recognized power interruption, upon MMU reset, or upon return from manual or time-of-day flash. The CU shall be programmable from a closed loop computer system, a laptop computer using the RS232 port, front panel programming, and by downloading from another like CU through the RS232 port.*

Keystroke buttons shall be clearly marked as to function. All programming buttons and indicators pertinent to the operation of a phase shall be on the front of the CU and shall have programmable phase omitting and phase skipping capabilities.

The TS2 type A2 CU shall be in accordance with all applicable requirements for a type A2 CU as defined by NEMA TS2-3 and shall contain a full compliment of connectors.

210 **3. Internal Modules**

All plug-in modules shall be equipped for easy removal or installation without the use of tools and shall be readily accessible for maintenance. All internal module plugs and edge card plugs shall have the corresponding pin connector position labeled with the first and last numbers or the first and last letters.

4. CU Enclosure

220 *The enclosure shall be of adequate strength to protect the components during normal handling. The keypad, liquid crystal display and all interface connectors required for the operation and standard field adjustments shall be mounted on the front panel. Fusing shall be on the front panel of the CU and shall provide protection from internal or external overload.*

The front panel of the controller shall be fastened to the frame such that no special tools shall be required to remove or replace printed circuit board modules nor to gain access through the front panel. All hinges shall have stainless steel pins.

5. Firmware and Software Revisions

230 *The Department's Logistical Support Center shall be notified each time an update or revision of the firmware or software is released, explain the changes, and the benefits of the change. The Department will determine if and to what extent a revision is to be placed into field operation and may fully re-evaluate the CU with the revision.*

(f) NEMA TS2 Cabinet, Auxiliary Equipment, and Terminal and Facilities, TF, Requirements

240 *These standards define the minimum requirements for a TS2 type A1 cabinet, both inside and out. The performance and construction of the cabinet shall be in accordance with the applicable requirements of NEMA TS2 sections 4, 5, 6, and 7. The serial number and model number of the auxiliary equipment shall be permanently applied externally on or near the front of the product. Programming and maintenance manuals for approved products shall be identical in nature to that approved for use during the evaluation period of the product. The Department shall be notified of all changes to the documentation. Manufacturer specific enhancements are acceptable, however no function or device shall preclude the interchangeability of an auxiliary product with another product of like NEMA specification within a controller assembly.*

1. Controller Cabinet Requirements

The NEMA TS2 type A1 controller cabinet shall be in accordance with the following requirements.

250 **a. General**

The cabinet and the shelves shall be fabricated of aluminum. The cabinet shall be 1/8 in. (3.18 mm) minimum thickness sheet aluminum or 1/4 in. (6.35 mm) minimum thickness die-cast aluminum. The cabinet exterior and interior including shelves shall have a sandblasted, roughened, or chemically etched finish that reduces gloss, reflection, and glare.

260 *The main cabinet door shall use a Corbin lock No. 2 and each cabinet shall be furnished with 2 No. 2 keys. The lock shall open in a counterclockwise motion only. The door shall be capable of being opened and stopped in at least the following 2 ranges of degree opening as measured from the face of the cabinet door on the hinged side: 80 to 100°, and 170 to 190°. The door shall be hinged on the right side of the cabinet. The main door and the police panel door shall close against a weatherproof and dustproof gasket seal, which shall be permanently bonded to the cabinet. A standard police panel key shall be provided with each cabinet.*

270 *A rain channel shall be incorporated into the design of the main door panel to prevent liquids from entering the enclosure. A 1 1/2 in. (38 mm) deep drawer shall be provided in the cabinet, mounted directly beneath the controller support shelf. The drawer shall have a hinged top cover and shall be capable of accommodating 1 complete set of cabinet prints and manuals. This drawer shall support 50 lb (23 kg) in weight when fully extended. The drawer shall open and close smoothly. Drawer dimensions shall make maximum use of available depth offered by the controller shelf and be a minimum of 24 in. (610 mm) wide.*

b. Switches, Auxiliary, and Environmental Feature Requirements

280 *The cabinet shall have a police door and a police control panel within the main door. The police panel shall have 2 different switches, 1 switch for field indication cutoff and 1 switch to transfer between automatic signal control and flashing operation. The switches shall be protected from water when the cabinet door is open.*

290 *A test switch panel shall be mounted on the inside of the main door. The test switch panel shall include, as a minimum, the following switches. An auto/flash switch shall be installed so that when in the flash position, power shall be maintained to the controller and the intersection shall be placed in flash. A stop time switch shall be installed so that when in the 'On' position the controller shall be stop-timed in the current interval. A controller equipment power On/Off switch shall be installed which shall control AC power to the CU, MMU, and cabinet power supply. All switches mounted on the switch panel on the inside of the main door shall have in place a mechanism to prevent accidental activation of the switch. "Locking bat" type switches or side switch guards are acceptable. Switch guards, if used, shall be in place for each switch, shall be made of the same material as the cabinet, and shall permit the operation of the switch without the use of tools.*

All switch functions shall be permanently and clearly labeled. Hand written labeling will not be permitted.

The cabinet shall include all required wiring, connectors and adapters to provide full compatibility and interchangeability with either a TS2 type A1 or type A2 controller.

300 **c. Receptacle**

The cabinet shall contain 1 duplex convenience outlet and a lamp receptacle that is actuated and turns on when the door is open and goes off upon closing of the door and an internal On/Off switch which can override the preceding. The convenience outlet shall be duplex, 3-prong, NEMA type 5-15R grounding outlet in accordance with NEMA WD-6, with ground-fault circuit interruption as defined by the National Electric Code. These units shall be protected with a 15-ampere cartridge fuse wired ahead of the multi-breakers.

310 *Master cabinets shall have an additional duplex, 3-prong, NEMA type 5-15R grounding outlet. This outlet shall be powered by the 10-ampere circuit breaker and through a separate power interrupt switch providing separate control of the master CU power supply.*

d. Fan and Filter

320 *The cabinet shall contain a thermostatically controlled ventilating fan and a vent with a commercially classified uniform 1 in. (25 mm) thick filter. The thermostat shall be manually adjustable from 90 to 115°F (33 to 45°C). The fan shall be mounted internally at the top and toward the front of the cabinet to exhaust out the front top lip of the cabinet. The fan shall be rated at a minimum of 100 cu ft (3 m³) per minute as designated by NEMA TS2-7.9.1. The thermostat shall be located within 6 in. (150 mm) of the fan.*

The filter size will be according to the provisions for the type of cabinet as stated in NEMA TS2-7.9.2.3 and shall be a replaceable pleated air filter with a minimum efficiency reporting value, MERV, rating of 5 or higher as defined by the ASHRAE 52.2-1999 specification. The cabinet ventilation shall be in accordance with NEMA TS2-7.9.

Each inductive device, including the fan, shall have a separate power surge protection.

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2. Load Switch and Flasher Requirements

The cabinet shall contain a jack mounted type 3 solid state non-repairable flasher in accordance with NEMA TS2-6.3 electrical and physical dimensions.

The pedestrian load switch and the signal load switch shall be an approved unit meeting all electrical and physical dimension requirements in accordance with NEMA TS2-6. The load switch shall not use a printed circuit board to transmit the 115V AC line input or signal buss output. Each load switch shall offer 3 indicators, 1 for each circuit indicating the status of the input to the load switch.

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The load switch signal outputs shall be brought to a separate terminal strip for hook-up of the signal displays. Load switches inputs shall be capable of being programmed for flash, overlap, vehicular, or pedestrian phases with the use of a standard slotted or phillips screwdriver via the cabinet terminal strip. The load switch input programming of the TS2 type A1 CU shall be accomplished through front panel data entry of a TS2 type A1 or a TS2 type A2 CU.

3. Terminal and Facilities Requirements

a. General Requirements

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The TF layout shall be in accordance with NEMA TS2-5.2.7. The cabinet shall contain a main TF panel complying with NEMA TS2- 5 standards. The model number of the main panel shall be permanently applied to the front of the panel, where it is easily readable, without removing or disconnecting the panel. Each controller input and output circuit shall terminate on the main TF panel or on a supplementary panel. The phase arrangement of the controller shall coincide with the channel arrangement of the load switches and MMU. All outputs on channels 9 through 12 field connections shall have a 1 μ F capacitor placed at each output terminal on the front of the TF panel. All TFs within the cabinet shall be readily accessible for field connection without removing the controller or associated equipment and for maintenance in the cabinet. All stranded wiring shall be tinned. A 24 volt relay shall be used on the TF to remove 24V DC from the common side of the load switches, effectively taking the mercury relay out of the circuit when the signal is put in mechanical flash. The TF panel shall be hinged at the bottom and capable of swinging down, to allow accessibility of the wiring and terminals at the rear of the panel. The backpanel shall be attached to the cabinet such that access to the backside of the backpanel, for maintenance purposes, shall be accomplished without the use of special tools or removal of auxiliary panels, shelving, or other cabinet appurtenances. A bracket extending at least half the length of the NEMA load switch shall support all load switches.

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Terminals shall be consecutively numbered on both sides of the TF panel and shall be in compliance with the appropriate schematic diagrams. All positions for load switches, flasher, and mechanical relays shall have reference designators on both sides of the TF panel. All nomenclature shall be on or adjacent to the component or terminal. All nomenclature shall be machine produced and not handwritten. Cabinet prints shall identify the function of each terminal position.

380 *CU and MMU harness cables shall be of sufficient length to allow units to be placed on either shelf or on top of the cabinet while remaining in operational mode. RS485 port 1 communications cable shall also be of sufficient length to allow any port 1 cable to be utilized with any TS2 unit within the CA. The RS485 harness shall be constructed of a high quality shielded communications cable. The TF panel shall contain a resistor/capacitor network circuit which will provide an external restart pulse to initiate the startup sequence upon initialization from flash.*

Remote flashing shall be provided for all signal circuits. Unless otherwise indicated on the plans, phases 2 and 6 shall be wired to flash yellow. All other phases shall be wired to flash red. Flashing for signal circuits shall be activated on 1 circuit for odd numbered phases and on the other circuit for even numbered phases.

390 ***b. Power Panel Requirements***

400 *A transparent plexiglass cover shall be provided over the CA power supply panel. The cover shall leave the switches on the breakers exposed as well as leave access to terminals at the bottom of the panel for wiring purposes. No terminals on the power panel shall have silicon protectant on them in lieu of the plexiglass cover. The panel shall contain a multi-breaker with one 10 A circuit breaker to provide overload protection to the CU, MMU, BIU, +12/24V DC cabinet power supply, and detection devices. It shall also contain 1 main circuit breaker of 35 or 40 A, to provide over-load protection to the signal and flash buss load. All breakers shall have line and load terminals clearly labeled. The signal bus shall be connected to the incoming AC line through a mercury contact switch or a solid state control device functionally equivalent to the NEMA 5.4.2.3 specified contact switch. The terminals for AC + and - input to the cabinet shall be capable of accepting a No. 6 wire.*

410 *With the CA 10 A and main 35 or 40 A circuit breakers 'Off' (tripped), all units inside the cabinet and the intersection display shall be 'Off'. With the 10 A breaker 'On' and main 35 or 40 A circuit breaker 'Off', the signal output shall be 'Off' and the major units within the cabinet shall function. With the 10 A breaker 'Off' and main 35 or 40 A circuit breaker 'On', the intersection shall be in flash mode and all units within the cabinet will be 'Off'.*

420 *The cabinet shall contain a 50 kA 8 x 20 μ s surge suppressor. The surge suppressor shall be a 120V AC, 15 A, minimum 2-stage parallel/series type device and protect lines: line-neutral, line-ground and neutral-ground, have a maximum continuous operating voltage of 140V AC, maximum clamp voltage of 350 volts and device status indicators of green/good and red/failed. The device shall plug into a NEMA 12 position terminal base wired before and in parallel with the 35 or 40 A main signal buss circuit breaker and in series with the 10 A circuit breaker for the solid state equipment and provide for a tool-free replacement of the device. There shall be a minimum of 2 electrical receptacles on the equipment side of the device for future auxiliary equipment. The surge suppressor shall operate between -30 to 165°F (-34 to 74°C). The dimensions of the unit shall not exceed 4 1/2 in. (114 mm) wide by 7 in. (178 mm) long by 3 1/2 in. (89 mm) deep.*

All equipment capable of operating at 12 or 24V DC typically powered by an individual receptacle type power supply shall have a power cable permanently wired into the cabinet and the device shall be powered by the cabinet TS2 power supply

4. MMU Requirements

430 *The cabinet shall contain a MMU and shall be in accordance with the standards of NEMA TS2- 4. The MMU shall be wired to monitor each load switch output.*

5. BIU Requirements

All BIU's shall be in accordance with NEMA TS2 1998, Section 8. Edge mounted printed circuit boards and rack cards shall not have jumper wire modifications unless the jumper wires are permanently bonded to the PCB over its entire length. BIU's shall be supplied with each cabinet to allow for maximum phase and function utilization for which the cabinet is designed.

6. Loop Amplifier Units and Rack Requirements

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a. General

450 *All loop amplifier units shall be in accordance with NEMA TS2-6 and shall follow type C, 2 channel with delay and extend, as stated in NEMA TS2-6.5.2.2.1. All amplifiers shall be selected from the Department's List of Approved or Prequalified materials for each type of amplifier. In addition, loop amplifiers shall have an LCD display or a RS232 serial data connection and software interface capable of displaying loop status including but not limited to operating frequency and $-\Delta L/L$, diagnostics, and all amplifier settings and operating parameters. Edge mounted printed circuit boards and rack cards shall not have jumper wire modifications unless the jumper wires are permanently bonded to the PCB over its entire length.*

All detection components including amplifiers, racks, auxiliary BIU, interface panels, lead-ins, and all connecting harnesses shall provide 1 count output channel per lane of each approach within project limits.

460 *All loop amplifiers designated for counting shall meet all requirements as above and shall additionally transmit channel 1 and 2 count pulses on the edge connection assigned to channels 3 and 4 respectively. Counting amplifiers shall be configured with count outputs mapped to and recorded in the CU detector logs. The status output of each active counting channel (3 and/or 4) shall be set to logic ground by software configuration within the amplifier or externally by use of jumper card in the adjacent slot.*

An auxiliary BIU panel may be used strictly for count outputs (channels 3 and/or 4 only); in this configuration, the status outputs for those count output channels may be wired to logic ground on the BIU panel. The status outputs for all standard output channels shall provide accurate status data at all times. All detector input data to the CU shall remain accurate at all times.

470 *All size 5 (M) and size 6 (P-1) cabinets shall incorporate a 16 channel detector rack, configuration No. 2, as per NEMA TS2-5.3.4 and shall allow operation of a 2*

channel detector in each slot and the capability of operation of a 2 channel counting amplifier in each even-numbered slot with the respective count outputs in each odd numbered slot. The number of detector racks provided shall be determined by the loop tagging table. All size 3 (G) cabinets shall incorporate an 8 channel detector rack, configuration No. 1, as per NEMA TS2-5.3.4.

All detector loop panels and detector racks shall be labeled according to the loop tagging table and as follows.

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All detection shall be labeled in such a way that the numbering for any loop is consistent throughout the cabinet; the loop terminated as Loop or Detector 17 shall be Detector Channel 17 in the detector rack and Detector Input 17 to the controller.

b. Loop Termination Panel

Each loop lead-in panel shall be labeled on the upper left corner with the loop numbers that are terminated on that panel as follows: (1-16), (17-32), (33-48), (49-64). Each loop termination point shall be labeled with the corresponding loop number. Example: For panel 17-32: loops terminated on this panel will start with 17 and end with 32.

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c. Detector Rack

Each detector rack shall be labeled at the bottom of the rack with a continuous label. The label shall be 1 in. wide, thermal printed black on clear, white or matte polyester tape with permanent adhesive, water, chemical and scratch resistant printed with 4 lines of Arial, size 10 font. Below the BIU shall be the BIU number and detector channel numbers that are contained within the rack as follows: (1-16), (17-32), (33-48), (49-64). This area shall also contain the intersection for diamond interchanges controlled from 1 cabinet. Each slot shall be labeled below the module with the corresponding loop tag information; the count output number portion of the information shall be under the first part of the tag information. For each 2-channel module, channel 2's label shall be below channel 1's label.

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7. Cabinet Power Supply Requirements

The TS2 cabinet power supply shall adhere to the guidelines of NEMA TS2-5.3.5. The power supply shall be encased on all sides so that no circuitry is exposed to the user.

8. Cellular Modems

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a. Service Provider

All data, power and antenna cables and all supplemental hardware shall be provided. The modem shall be compatible with the Department's current cellular carrier/provider (Verizon as of 07/07) and the traffic control device and closed loop communications software that it is supplied for.

b. Modem Hardware

Cell modems shall be Airlink Raven CDMA C3211 or similar modem with the following specifications: The cellular modem shall be capable operating in CDMA dual mode (both 800 MHz cellular and 1.9 GHz PCS bands), supporting both circuit switched

520 *and IXRTT packet switched services. The operating voltage range shall include 12V and 24V DC and shall draw less than 250 mA while transmitting and receiving at 12V DC. The modem shall have LED indications for power, signal status/strength, and TX/ RX either separately or combined. The serial interface shall be RS232 with a DB9 (male or female) connector.*

c. Modem Antenna

The RF antenna connection shall be a 50 Ω TNC connector. The antenna shall be a low profile, puck style, flat mount dual band, (800 and 1900 MHz) with low loss RG58 cable and TNC connector.

530

d. Modem Software

The modem configuration shall be editable and viewable with MS-Windows provided software or with proprietary software that is included and designed to run on a MS-Windows operating system. The software shall auto-detect connection parameters and display settings when connected.

e. Installation

540

Service and activation shall be requested and/or confirmed for each cellular device to be installed prior to installation. The ESN and 10-digit phone number shall be clearly labeled on the exterior of the modem. The cellular modem shall be installed, configured and tested to allow data communication from the central closed loop software to the field master and subsequent secondary controllers, or directly to a secondary controller per the design. All data, power and antenna cables and all supplemental mounting hardware shall be installed. The modem shall be powered by the cabinet power supply from a terminal location on the cabinet back panel or the power distribution panel. A low profile antenna shall be mounted externally and the mounting location includes a watertight seal. The antenna shall have no more than 3 ft excess RG58 cable in the cabinet.

550

9. Radio Interconnect Using Spread Spectrum Radio Modems

Spread spectrum radio modems for communications between local controllers and the system master controller shall be on the Department's list of approved Traffic Signal and ITS Control Equipment and shall be in accordance with ASTM E 2158, and as set out herein.

560

The spread spectrum radio modems shall provide all the needed features to communicate with NEMA TS2 type 1 and type 2 traffic signal controllers in a coordinated closed loop system. The radio modems shall be software configurable to be either a master, repeater, repeater/slave, or slave radio. The radio modem shall require no user license from the FCC; operate in the 900 MHz range, and be of frequency hopping spread spectrum, FHSS, technology; support data rates from 1.2 kbps to 115.2 kbps asynchronous; have a receiver sensitivity of at least -110 dBm; have a minimum RF output level of 1 watt; have a minimum of 50 user-selectable hopping patterns and a minimum of 50 RF non-overlapping channels allowing multiple systems to operate in the same line-of-sight path; operate as a transparent RS232, or RS422/RS485, or FSK 1200 baud types of links for use in a point-to-multipoint system; have an external SMA female type or N-female RP-TNC female antenna connector; and be supplied with power supply

570 for 120V AC operation. The modems shall be rack or shelf mounted in standard NEMA TS2 type 1 or type 2 cabinets. The modems shall have an operation temperature of -40 to 176°F (-40 to 80°C), have a maximum current draw of 500 mA for the transmission of 1 watt of RF output power, while operating on 12V DC. Lighting and transient protection on all data lines and antenna connector, and AC/DC power distribution, shall be provided with the system.

580 The spread spectrum radio modems must include a Windows based, configuration software package, which will include a graphical user interface, GUI, allowing for ease of programming, through pre-written drivers for all Department approved traffic controllers and have the ability to automatically determine, and connect, at their radios baud, stop and parity settings. The configuration software must allow for signal level, RSSI, data integrity, message polling, and spectral analysis testing. The software must also permit all the radios within a system to be configured from a single location. All radio equipment and cables shall be delivered preconfigured and ready for field operation.

The manufacturer, or vendor, shall supply with each modem, the operational manual containing procedures for all features incorporated in the modem.

a. Transient Protection

590 Transient protection shall be installed between the radio modem and the field antenna. The transient protection shall be flange mounted in the cabinet and have a minimum transient current of 40 kA for 8 x 20 μs pulse, an insertion loss or ≤ 0.1 dB, have an operating frequency in the 900 MHz range, allow throughput energy to be ≤ 220 μJ for 6 kV /3 kA @ 8/20 μs waveform, have throughput voltage ≤ 144 Vpk, and turn-on voltage shall be ± 600 volts. The unit impedance shall be 50 Ω.

b. Antennas

600 The antenna for the radio modem at the system master/local controllers shall be capable of providing a transmission range adequate for communication with all radio modems or repeaters in the system and must be configured as a single omni, single-yagi, or dual-yagi (2 single-yagi antennas on differing alignments) for each radio as described below.

(1) Omni Antennas

610 All omni antennas shall be capable of producing between 6 dBd and 10 dBd (8.15 dBi and 12.15 dBi) of gain while operating in, and covering the entire 902-930 MHz frequency range. The voltage standing wave ratio, VSWR, of the omni antenna shall be 1.5:1 or less when the antenna coax feed impedance is 50 Ω. Omni antennas shall be fabricated of fiberglass, brass, copper, and/or aluminum and shall be rated for wind velocities of at least 100 mph. The minimum length of the omni antenna shall be 60 in. and it shall be designed and fabricated with a fiberglass radome with a minimum diameter of 2 in. to prevent ice from collecting directly on the driven element. All omni antennas shall have a cableless N-female connector directly affixed and sealed to the antenna body. All hardware and fastenings devices shall be fabricated from stainless steel.

(2) Yagi / Dual-Yagi Antennas

620 All yagi antennas shall be capable of producing between 10 dBd and 13 dBd (12.15 dBi and 15.15 dBi) of gain while operating in, and covering the entire 902-930 MHz frequency range. The voltage standing wave ratio, VSWR, of the omni antenna shall be 1.5:1 or less when the antenna coax feed impedance is 50 Ω . The front to back ratio must be at least 20 dB for each yagi antenna. Yagi-directional antennas shall be fabricated of either anodized or powder coated 6061/T6 aluminum rod and seamless drawn pipe and shall be rated for wind velocities of at least 100 mph. All yagi antennas shall have a cableless N-female connector directly affixed and sealed to the antenna body. The yagi antenna shall be designed and fabricated so that polarization changes (vertical to horizontal) can be made on the antenna mount without adjusting the mast. Single yagis shall be connected by a low loss N-female "T" splitter/coupler and LMR-400 cable to form dual-yagi systems. All hardware and fastenings devices shall be fabricated from stainless steel.

630

c. Antennas Cable and Hardware

The coaxial cable used as the transient protection to antenna lead shall have no greater than 3.8 dB loss per 100 ft of length and shall be LMR-400.

All LMR-400 connections are to be stripped, deburred, and crimped using the ST-400-EZ LMR-400 stripping tool, DBT-01 LMR-400 deburring tool, and a 0.429 in. hex crimp die for solderless LMR-400 connections respectively. All connections shall be completely sealed by heat shrinking double walled, adhesive lined shrink tubing for weather proofing and strain relief.

640

Cables shall be included to interface the radio equipment to the transient protection. The antenna mounting hardware shall securely attach the antenna to the strain pole/cantilever arm. The coaxial cable fitting on the antenna shall not support the weight of the coaxial cable run to the base of the strain pole/cantilever arm.

d. Data Cables

650 Cables shall be included to interface the radio equipment to the system master, co-located secondary controller, remote secondary controllers and any communication interface panels as needed. Cables shall include strain relief back shells designed to mate and lock with the telemetry connector on the system master and local controllers. All radio equipment and cables shall be delivered preconfigured and ready for field operation.

All miscellaneous equipment necessary to complete the installation shall be as specified by the radio modem manufacturer.

(g) Cabinets

1. Size 3 (G) Cabinet

660 The size 3 (G) cabinet shall be pedestal-mounted or pole-mounted. As per NEMA TS2-5.3, the TS2 type 1 G cabinet, at minimum, shall house an 8-load switch bay (configuration 2) terminal and facilities panel and shall have 1 adjustable shelf located 12 in. (305 mm) below the top of the cabinet. The bottom of the cabinet shall be

reinforced to ensure a secure pedestal mounting. The G cabinet shall have dimensions of 25 in. (635 mm) wide, 38 in. (965 mm) high, 18 in. (460 mm) deep with a tolerance of ± 4 in. (100 mm) in any or all dimensions.

670 A cabinet slipfitter shall be used to attach the cabinet to the pedestal. The slipfitter shall fit a 4 1/2 in. (114 mm) outside diameter pipe and shall have a minimum of 3 set screws equally spaced around the slipfitter.

A vent of adequate size shall be provided. The size of the vent and the filter requirements shall be in accordance with the manufacturer's recommendations.

2. Size 5 (M) Cabinet

680 As per NEMA TS2-5.3, the TS2 type 1 (M) cabinet, as a minimum, shall house at minimum an 8-load switch bay (configuration 2) terminal and facilities panel and shall have 2 adjustable shelves with the first shelf located 15 in. (380 mm) below the top of the cabinet and the second located 7 in. (180 mm) below the first shelf.

The M cabinet shall be ground-mounted on a concrete foundation at locations and dimensions as shown on the plans.

The M cabinet shall have dimensions of 30 in. (760 mm) wide, 48 in. (1,220 mm) high, and 16 in. (410 mm) deep with a tolerance of ± 2 in. (± 50 mm) in any or all dimensions.

690 Anchor bolts shall be steel in accordance with ASTM A 36 (A 36M). Diameter of the bolt shall be 1/2 in. (13 mm) or 5/8 in. (16 mm) and the minimum length shall be 15 in. (380 mm) plus a 3 in. (75 mm) right angle hook on the unthreaded end.

The top 6 in. (150 mm) of the bolt shall be threaded with 13 NC threads on 1/2 in. (13 mm) bolts and 11 NC threads on 5/8 in. (16 mm) bolts. The hexagon nut, the flat washer, and the threaded end of the bolt shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

3. Size 6 (P-1) Cabinet

700 The size 6 (P-1) cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.02(g)2. As per NEMA TS2-5.3, the TS2 type 1 P-1 cabinet, at minimum, shall house a 16-load switch bay (configuration 3) terminal and facilities panel and shall have 2 adjustable shelves with the first shelf located 20 in. (510 mm) below the top of the cabinet and the second located 7 in. (178 mm) below the first shelf a minimum of 30 in. (762 mm) above the bottom of the cabinet, the second located 12 in. (305 mm) above the first shelf.

710 The cabinet shall be 44 in. (1,120 mm) wide, 52 in. (1,320 mm) high, and 24 in. (610 mm) deep with a tolerance of ± 3 in. (± 75 mm) in any or all dimensions. Maximum exterior dimensions shall be 47 in. (1,195 mm) wide, 63 in. (1,600 mm) high, and 34 in. (860 mm) deep.

4. Size 7 (R) Cabinet

720 The size 7 (R) cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.02(g)2. As per NEMA TS2-5.3, the TS2 type 1 R cabinet, at minimum, shall house a 16-load switch bay (configuration 3) terminal and facilities panel and shall have 3 adjustable shelves with the first shelf located a minimum of 30 in. (762 mm) above the bottom of the cabinet, the second located 12 in. (305 mm) above the first shelf and the third located 8 in. above the second shelf. All shelves shall be adjusted so that the second shelf is located 63 in. ± 3 in. (1,600 mm ± 75 mm) above the top of the concrete footpad.

The cabinet shall be 44 in. (1,120 mm) wide, 72 in. (1,830 mm) high, and 24 in. (610 mm) deep with a tolerance of ± 3 in. (± 75 mm) in any or all dimensions. Maximum exterior dimensions shall be 47 in. (1,195 mm) wide, 83 in. (2,110 mm) high, and 34 in. (860 mm) deep.

5. Flasher- Two Circuit Alternating Flasher

Two circuit alternating flasher shall be solid state.

730

a. General

The solid state flasher shall periodically interrupt a source of alternating current line power. Solid state shall mean electrical circuits, the active components of which are semi-conductors, to the exclusion of electromechanical devices or tubes.

The flasher shall be a type 3 solid state flasher conforming to Section 8 of the NEMA Standards Publication TS1-1983. The flasher output circuit carrying the signal load shall consist of opto or photo isolated solid state power relays and shall be hard wired to the flasher connector.

740

Three schematic diagrams and 3 descriptive parts lists shall be furnished with each flasher.

Two circuit alternating flashers shall be plug-in design. The flasher design shall not permit the unit to be inserted improperly into the plug-in base. The flasher shall have heavy-duty plugs and jacks capable of handling the rated load current. The rate of flash shall be 50 to 60 flashes per minute.

750

The flasher shall operate between 95V and 135V AC 60 Hz. No degradation of performance shall be experienced in environmental changes from -20 to 165°F (-29 to 74°C) and 0 to 90% relative humidity.

b. Cabinet Requirements

The cabinet shall be weatherproof and fabricated from cast aluminum or aluminum sheeting with a minimum thickness of 1/8 in. (3.18 mm). The cabinet door shall be the entire front of the cabinet and shall be hinged on the right or left side of the cabinet. A Corbin No. 2 lock and 2 No. 2 keys shall be furnished. The lock shall be located near the center of the door on the side opposite the hinge.

760 *Minimum dimensions for the cabinet shall be 12 in. (305 mm) deep, 12 in. (305 mm) wide, and 12 in. (305 mm) high. The maximum dimensions shall be 18 in. (460 mm) deep, 15 in. (380 mm) wide, and 18 in. (460 mm) high.*

The cabinet shall have 2 pole plates for stainless steel band mounting of the cabinet on a pole with a minimum diameter of 4 in. (100 mm) and a maximum diameter of 18 in. (460 mm). Two blank cover plates shall be provided. Two hub plates for 1 in. (25 mm) diameter conduit shall be provided with gaskets, 8 bolts at 4 bolts per plate, nuts, and washers for attaching the hub plates to the cabinet. The cabinet shall be drilled for the mounting of the pole plates or hub plates as shown on the plans.

770 *It shall have a screened vent in the bottom with a minimum size of 1 3/4 sq in. (1,129 mm²), and a minimum of 1 louvered and screened vent towards the top of the cabinet.*

The panel in the cabinet shall be capable of being removed and reinstalled with simple hand tools. A 25 ampere radio interference filter and surge arrestor wired ahead of a 15 ampere circuit breaker shall be mounted on the panel. A terminal block capable of the following electrical connections shall be mounted on the panel.

780 *Circuit 1 - for connection of field signals (flash circuit 1)
Circuit 2 - for connection of field signals (flash circuit 2)
Circuit 3 - for connection of field signals (field neutral)
AC plus - capable of accepting a No. 6 wire
AC minus - capable of accepting a No. 6 wire
Ground lug - capable of accepting a No. 6 wire*

922.03 Signal Head Components

790 *The components shall be in accordance with the Institute of Transportation Engineers for Adjustable Face Vehicular Traffic Control Signal Heads. All new traffic signal and flasher installations that include new indications shall be fitted with LED modules. All LED indications shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment.*

(a) General

The signal faces shall be sectional in construction, requiring 1 section for each lens and furnished in the nominal size of 12 in. (305 mm). Each section of a face shall have a rectangular silhouette when viewed from the front or the rear.

(b) Housing, Door, and Visor

800 *The top and bottom of each housing shall have an integral locking ring with 72 serrations to permit rotation of the signal housing in 5° increments. Hub openings in the top and bottom of the signal housing shall accommodate standard 1 1/2 in. (38 mm) bracket arms. The thickness of the hub at the top and bottom of the housing shall be a maximum of 1 in. (25 mm) and a minimum of 3/8 in. (10 mm). The 12 in. (305 mm) door shall have 2 simple locking devices. The door on the hinged side shall be attached with hinge pins. Each lens shall have the standard cap type visor. All screws, latching bolts, locking devices, and hinge pins shall be stainless steel.*

(c) LED Traffic Signal Indicator

810 *All LED indicators shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment.*

All LED indicators shall have a permanent indelible sticker affixed to the back of the module indicating month and year of initial installation.

All LED indicators provided shall be individually listed on a parts list indicating the contract number, vendor, category, manufacturer, model, serial number, and inventory number. Hard copy and electronic copies shall be provided. The electronic document shall be MS Excel (.xls) format and the blank worksheet shall be obtained from the Department's Logistical Support Center.

820

(d) Wiring

The field wiring leads shall be terminated with screw spade lug type connectors. The LED module wiring leads shall be terminated with 1/4 in. female type connectors for ease of connection to the terminal block.

(e) Section Coupling

Any method to connect 2 or more sections together may be used, if the following requirements are met:

830

- 1. Two or more sections, when jointed together, shall maintain structural integrity when loaded in accordance with Institute of Transportation Engineers Standards.*
- 2. The opening between joined sections shall accommodate two 1/2 in. (13 mm) cables.*
- 3. The maximum length of bolts used to connect sections together shall be 4 in. (100 mm).*

840

Nuts, bolts, and lock washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

(f) Terminal Block

The yellow section of the 3-section or 2-section signal head and each 1-section signal head shall be equipped with a 5-position terminal block for termination of field wiring. Each section shall have provisions for two 5-position terminal blocks. Each terminal screw shall have a 1/4 in. corresponding spade tab. The terminal block shall have a minimum spacing between screw connections of 1/2 in. (13 mm). The height of the insulating ridge between screw connections shall be a minimum of 19/32 in. (15 mm) from the base of the terminal blocks.

850

(g) Material Requirements

1. Polycarbonate Signal Head

The housing, door, and visor of the section shall be made of ultraviolet and heat stabilized polycarbonate. The color shall be permanently molded into the components except the inside surface of the visor shall be painted non-reflecting flat black. The color shall be yellow in accordance with 909.02(b).

860

2. Die-Cast Aluminum Signal Head

The housing, door, and visor of the section shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85. All surfaces of the housing, doors, and visor shall receive a prime coat of zinc chromate paint in accordance with 909.02(a) or shall be anodized with a chromate aluminum oxide coating process. The finish shall be highway yellow enamel, 2 coats, oven baked and in accordance with 909.02(b) except the inside surface of the visor shall be painted non-reflecting flat black.

870

(h) Certification

A material certification shall accompany each order certifying that a signal head from a normal production run within the past 12 months, passed the Institute of Transportation Engineers criteria for breaking strength and deflection. Deflection testing is not required in the certification for polycarbonate signal heads.

922.04 Pedestrian Signal Head

A pedestrian signal shall be 1 section and rectangular in shape. The dimensions of each side may vary from 18 to 19 in. (460 to 485 mm), including the visor and the hinges. The signal shall contain 2 figures with 2 different colored messages. The first figure shall transmit an upraised hand symbol message, and the second figure shall transmit a walking person symbol message. All new installations including new pedestrian indications shall use Light Emitting Diodes. All pedestrian LED indications shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment. The pedestrian signal shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

880

(a) Housing, Door, and Visor

The housing shall be equipped with mounting device hardware, such as clamshell, and round openings at top and bottom for mounting with brackets made of iron pipe standard, to fit the 1 1/2 in. (38 mm) pipe. The openings shall have a common vertical centerline through the housing to permit 360° rotation after it is mounted. The openings shall have a serrated ring which permits locking of the housing in 5° increments throughout the entire 360° of rotation. The brackets or the clamshell shall serve as the electrical conduit for the pedestrian signal. The housing shall be made of die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85.

890

The door on the front of the housing may be hinged from any side. The door shall be gasketed to maintain a weather-tight enclosure when secured to the housing. The door and the visor shall be made of the same material as the housing or of polycarbonate. All materials shall be clean, smooth, and free from flaws, cracks, blowholes, or other imperfections.

900

Each signal shall be provided with a visor.

The exterior of the housing shall be Federal yellow in color. The polycarbonate components shall be black in color, impregnated throughout. The metal components shall be painted with enamel in accordance with 909.02(c).

910

(b) Message

The upraised hand and walking person symbols shall each be a minimum of 11 in. (280 mm) in height. The width of the upraised hand symbol shall be a minimum of 7 in. (178 mm). The width of the walking person symbol shall be a minimum of 6 in. (150 mm). Message configuration, color, and size shall be in accordance with the standard of the Institute of Traffic Engineers for Pedestrian Traffic Control Signal Indications.

Each pedestrian signal shall be completely wired internally, and ready for connection of the field wiring. A suitable terminal block for connection of the internal wiring and the incoming field wires to the pedestrian signal head shall be provided in the signal housing.

920

The light source shall be designed and constructed so that if an electrical or mechanical failure occurs, the upraised hand and walking person symbols shall also remain dark.

922.05 Signal Bulbs

All new traffic signal and flasher installations that include new indications shall be fitted with LEDs in accordance with 922.03. The minimum design requirements for replacement light bulbs to be used in a traffic signal face shall be in accordance with the Institute of Transportation Engineers standard for traffic signal bulbs and as follows:

930

(a) Incandescent Bulbs

1. *Bulbs shall be 67 watt, 116 watt, or 150 watt for different kinds of indications, as specified below.*

INDICATION	WATTAGE
9 in. (230 mm) pedestrian	67
12 in. (305 mm) pedestrian	116
18 in. (455 mm) pedestrian	116
12 in. (305 mm) red.....	150
12 in. (305 mm) yellow and green	116
12 in. (305 mm) yellow and green arrows	150
Optically programmed heads.....	150

940

All bulbs shall have medium size, brass bases.

2. *Bulbs shall be designed for use in a horizontal position or a base-down position.*

950

3. *The light center length shall be 2 7/16 in. (62 mm) for 67 watt bulbs and 3 in. (75 mm) for 116 watt and 150 watt bulbs.*
4. *The filament shall be C9 design with a minimum of 7 supports. The 2 voltage supply leads may be counted as 2 of the 7 supports.*
5. *The maximum, overall bulb length for 67 watt and 116 watt bulbs shall be 4 3/8 in. (110 mm) and for 150 watt bulbs shall be 4 3/4 in. (120 mm).*
6. *All bulbs shall be clear and shall be 130 volt.*
7. *The 150 watt bulb shall be P25 or A21 size and shape.*
8. *The 67 watt and 116 watt bulbs shall be A21 size and shape.*
9. *All bulbs shall have 6,000 h minimum burning life.*

960

970

922.06 Disconnect Hanger Junction Box

Traffic signal disconnect hanger junction boxes shall consist of a span hanger, a balance adjuster, a disconnect hanger clevis, and a housing with a hinged door with a positive latching device. The span hanger, balance adjuster, and all related hardware shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The housing shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B 85. The balance adjuster fitting shall be made of ferrous or non-ferrous metal. When made of ferrous metal it shall be galvanized in accordance with the requirements for the components and related hardware as set out above.

980

The disconnect hanger shall be designed so that the maximum allowable space or play between the span hanger and the eye-bolt of the balance adjuster and between the balance adjuster and the disconnect hanger clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. (1.6 mm). The span hanger bolt where the eye-bolt or the balance adjuster is attached shall be 5/8 in. (16 mm) diameter.

990

When serrated locking rings are not integrally cast in the components, the component and locking ring shall be designed so that when the locking ring is placed flush against the component, the component and locking ring shall not rotate or slide when torque is applied. The serrated components shall have 72 serrations to permit rotation of the disconnect hanger clevis, hub plate, or signal head in 5° increments. There shall be no thread in contact with a wearing surface. Locking rings shall have a minimum thickness of 3/16 in. (4.8 mm) and a maximum thickness of 1/4 in. (6.4 mm) from the base of the ring to the serration peaks. The inside diameter shall be 2 in. (50 mm) and the outside diameter shall be 2 7/8 in. (73 mm).

1000 *The terminal block shall have an 18-point terminal block permanently engraved or etched with sequential numbers indicating the circuits. The terminal block shall not have a method of connection which allows a screw point to damage wires when the wires are securely connected. Each point of connection shall accommodate a minimum of four No. 14 gauge (2 mm) wires.*

The disconnect hanger shall have 2 side entrance holes on opposite sides capable of receiving a 1 1/2 in. (38 mm) plastic or rubber insert to reduce water infiltration. It shall be capable of supporting signal faces in the ambient temperature range of -35 to 120°F (-37 to 49°C) without failure.

1010 *The balance adjuster shall have hex head bolts, lock washers, and nuts for securing the main body of the balance adjuster firmly onto and around the eye-bolt to prevent any twisting or turning of the head suspended below it. The span hanger shall have 2 J-bolts, lock washers, and hex head nuts adequate in size to securely fasten the hanger to a messenger cable up to 1/2 in. (13 mm) in diameter.*

A type C certification in accordance with 916 shall be provided.

922.07 Free Swinging Signal Support Assemblies

1020 **(a) Clearance**

The maximum allowable space or play between the hanger assembly and the eyebolt of the balance adjuster and between the balance adjuster and the weatherhead clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. (1.6 mm). No bushings or shims will be allowed in this assembly.

(b) Balance Adjuster

1030 *The balance adjuster shall consist of a hex head bolt, a lock washer, and nuts for securing the main body of the balance adjuster onto and around the threads of the eye-bolt to prevent any twisting or turning of the adjuster.*

(c) Span Hanger

1040 *The span hanger, balance adjuster, weatherhead, and all related hardware shall be made of a non-corrosive metal or shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The weatherhead shall have a minimum of 2 1/2 in. (64 mm) of exposed threads. The weatherhead shall have 2 set screws to fasten the nipple to the weatherhead. If the weatherhead and threaded pipe has a slip-in connection, the locking device shall be a double nut assembly. If the weatherhead and threaded pipe has a screw-in connection, the locking device shall be a double set screw assembly.*

The span hanger shall be furnished with 2 each of J-bolts, lock washers, and hex head nuts. The J-bolt shall be a minimum of 1/4 in. (6.4 mm) diameter and shall have sufficient threads to be able to secure the hanger to a 1/4 in. (6.4 mm) or to a 1/2 in. (13 mm) span cable.

(d) Tether Bracket

1050 The tether bracket shall attach to a 1/8 in. to 1/4 in. messenger cable and prevent the bottom of the head from moving side-to-side on the cable. Where backplates are installed on the signal heads; the tether bracket shall be of the proper length for the backplate so that the cable is mounted below the bottom of the backplate to avoid interference with head alignment and damage to the backplate.

(e) Pipe Arm Assemblies

The multiple pipe arm assembly shall consist of a span hanger assembly, a balance adjuster, a signal weatherhead, a 2, 3, or 4 way pipe arm, 1 1/2 in. (38 mm) pipe, a lower arm assembly, and all related hardware necessary for a complete assembly.

1060 The 2, 3, or 4 way pipe arms shall have a minimum of 2 in. (50 mm) of exposed thread. Each arm of the pipe arm shall be furnished with two 72 serration locking rings. One locking ring shall have a 3 in. (75 mm) outside diameter and one locking ring shall have a 2 3/8 in. (60 mm) outside diameter.

ASSEMBLY	MAXIMUM ALLOWABLE WEIGHT
2 Way	19 lbs (8.6 kg)
3 Way	25 lbs (11.3 kg)
4 Way	28 lbs (12.7 kg)

1070 **922.08 Signal Cantilever Mount Signal Bracket**

The bracket shall permit the following 4 adjustments:

- (a) rotational adjustment about bracket axis;
- (b) vertical adjustment;
- (c) rotational adjustment about signal cantilever arm; and
- (d) rotational adjustment right and left from vertical plane

1080 The bracket shall be fastened to the supporting arm or structure with stainless steel bands. The bracket shall adjust to fit all sizes of round, octagonal, elliptical, or other shape structure without special tools or equipment.

The bracket shall attach to the signal by clamping the signal head both top and bottom and shall be designed to accommodate the specified signal configuration. Each bracket shall be complete with all necessary hardware to attach the traffic signal to the bracket and the bracket to the support.

1090 All electrical wiring shall be concealed within the bracket, except that which runs from the bracket to the signal cantilever arm.

Upper and lower arms shall be cast from aluminum in accordance with ASTM B 26 (B 26M), alloy 713.0-T5 or 356.0-T6. The vertical support tube shall be extruded

from aluminum in accordance with to ASTM B 241 (B 241M), alloy 6063-T6 or 6061-T6, and the strapping to attach the bracket to the arm shall be stainless steel. All steel or malleable iron parts shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C.

1100

922.09 Pedestal Poles and Cast Aluminum Pedestal Bases

The pedestal base used for mounting pedestrian signal heads or control cabinets shall be in accordance with 922.09(a). The length of the pedestal pole shall be as shown in the plans.

(a) Cast Aluminum Pedestal Base

A pedestal mounted G cabinet shall have a cast aluminum pedestal base. The cabinet and pedestal base shall be ground mounted on a concrete type A foundation at locations and dimensions as shown on the plans.

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The cast aluminum base shall be made of aluminum in accordance with ASTM B 179, alloy ANSI 319.1 or 319.2, or in accordance with ASTM B 26 (B 26M), alloy ANSI 356.0-T6. The square base shall include an access door and anchor bolts with nuts and washers. The base shall be 13 3/8 in. (8,630 mm) square and 15 in. (380 mm) in height \pm 1/4 in. (\pm 6 mm). The weight shall be 22 lbs \pm 5% (10 \pm 2.2 kg).

1120

The base shall be designed to support a 150 lbs (68 kg) axial load and 11 sq ft (1 m²) of signal head area rigidly mounted. For design purposes, the distance from the bottom of the base to the center of the signal head area is 18 ft (5.5 m). In addition to the dead load, the base shall be designed to withstand wind and ice loads on the specified signal head area and on all surfaces of the support, in accordance with the AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Wind speeds used for design shall be based on a 10 year mean recurrence interval and a wind drag coefficient of 1.2 or as shown in the plans. The base shall contain an access door, which is 8 by 8 1/4 in. \pm 1/4 in. (200 by 210 mm \pm 6 mm) with a stainless steel hex head bolt for attaching the door.

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The base shall be attached to a foundation by 4 anchor bolts, with an anchor bolt circle of 12 3/4 in. (324 mm). Slotted lugs shall be integrally cast into the 4 corners of the base for attachment of the anchor bolts. The anchor bolts shall be steel in accordance to ASTM A 36 (A 36M). The diameter of the anchor bolt shall be 3/4 in. (19 mm) with a minimum length of 18 in. \pm 1/2 in. (460 mm \pm 13 mm), plus 2 1/2 to 3 in. (64 to 75 mm) right angle hook on the unthreaded end. The top 4 in. (100 mm) of the bolt shall be threaded with 10 NC threads. The threads, plus 3 in. (75 mm), shall be coated after fabrication in accordance with ASTM A 153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. Each anchor bolt shall be provided with 2 hex head nuts in accordance with ASTM A 325 (A 325M) and 3 washers. Two of the washers shall have a minimum 2 in. (50 mm) and maximum 2 1/8 in. (54 mm) outside diameter and be in accordance to ANSI B 27, type B regular series and one shall be a nominal 3/4 in. (19 mm) series W washer, in accordance with ASTM F 436 (F 436M).

1140

The cast aluminum pedestal base shall be in accordance with the dimensions and requirements shown in the plans. The casting shall be true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, and blowholes; and free from other defects in positions affecting the strength and value of the intended use for the casting. The base shall not have sharp unfilleted angles or corners. The surface shall have a workmanlike finish.

1150 *The door and bolt for the door shall be interchangeable on cast bases from the same manufacturer.*

(b) Pedestal Pole

The top of the base shall accommodate a pole having a 4 1/2 in. (114 mm) outside diameter. The threads inside the top of the base shall be 4 in. (100 mm) national standard pipe threads. The pole shall be either a steel pedestal pole or an aluminum pedestal pole.

1160 *A steel pedestal pole shall be a seamless schedule 40 carbon steel pipe in accordance with ASTM A 53, grade B. The pole shall have an outside diameter of 4 1/2 in. (114 mm). The pole shall weigh approximately 10.8 lbs/ft (16 kg/m). The length of the pole shall be as shown on the plans. The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 2 1/2 in. (64 mm). The pole shall be galvanized, after threading, in accordance with ASTM A 123. The threads shall be cleaned of all excess galvanizing and protected by a suitable shield.*

1170 *An aluminum pedestal pole shall be in accordance with ASTM B 241 (B 241M) for seamless aluminum alloy, schedule 40, 6061-T6. The outside diameter of the pole shall be 4 1/2 in. (114 mm). The length of the pole shall be as shown on the plans. The pole shall weigh approximately 3.7 lbs/ft (5.5 kg/m). The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 2 1/2 in. (64 mm) and protected by a suitable shield. The pole shall have a spun finish.*

(c) Pole Cap

A pole cap shall be supplied for the top of the pole if the pole is used for the mounting of pedestrian signal faces or side mounted signal control cabinets. The pole cap shall be either a cast pole cap of aluminum or a pole cap of spun aluminum.

1180 *A cast pole cap shall be made of aluminum, in accordance with ASTM B 179, alloy ANSI 319.1 or 319.2. The cap shall fit freely on the 4 1/2 in. (114 mm) outside diameter pole. A set screw using a 3/4 in. (19 mm) No. 12 hex head machine screw shall be supplied to hold the cap on the pole. A standard foundry draft will be allowed on the casting.*

A pole cap made from spun aluminum shall be in accordance with ASTM B 209 (B 209M), alloy 1100-0. The cap shall fit tightly when placed on the end of the pole.

922.10 Signal Supports

(a) Steel Strain Pole

1190 *The steel strain pole shall be an anchor base type pole and shall include a handhole and a pole top or cap. The poles shall be furnished in lengths specified.*

The pole shall have a reinforced handhole within 18 in. (460 mm) of the base. The handhole minimum size shall be 5 by 8 in. (130 by 200 mm) with a cover and latching device. The pole shall have a top or cap with a set screw that can be removed with small hand tools.

1200 *The pole material shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 50,000 psi (345 MPa). The pole shall be galvanized after fabrication in accordance with ASTM A 123.*

All hardware, handhole cover and latching device, band type steel polebands, steel bolts, nuts, and washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153, class C. All nuts and bolts, except anchor bolts, shall be in accordance with ASTM A 307. If a cast pole top or cap is used it shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (0.610 kg/m²).

1210 *The polebands shall fit the pole as planned. The wire rope shall not be in contact with any 90° edges or with any threads on the band. The pole band material shall be in accordance with ASTM A 572, grade 50 (A 572M, grade 345); ASTM A 606; or ASTM A 36 (A 36M) with minimum yield of 50,000 psi (345 MPa). The minimum width of the bands shall be 3 in. (75 mm) and the bands shall be capable of supporting the pole design load. Each half of the band shall be stamped with the corresponding size number.*

1220 *All welding shall be in accordance with 711.32. Welds shall generate the full strength of the shaft. Only longitudinal continuous welding shall be permitted on the pole shaft. Contacting joint surfaces shall be thoroughly cleaned before fabrication then completely sealed by means of welding. Working drawings shall be submitted in accordance with 105.02.*

The pipe coupling for the weatherhead and base plate shall be installed prior to galvanizing. The threads shall be cleaned of all excess galvanizing. An internal J-hook shall be installed near the top of the pole for wire support.

1230 *The steel strain pole shall be capable of supporting a 8,000 lb (35.6 kN) load applied horizontally 18 in. (460 mm) below the top of the pole with a maximum allowable deflection of 0.16 in. (4.1 mm) per 100 lb (445 N) of load. The pole shall be tapered 0.14 in./ft (12 mm/m) of length.*

A one piece base plate shall be secured to the base of the pole and shall develop the full strength of the pole. The base plate material shall be in accordance with ASTM A 36 (A 36M), A 572 (A 572M), or A 588 (A 588M). The base plate shall have 4 holes of adequate size to accommodate 2 1/4 in. (57 mm) anchor bolts. The bolt circle shall have a 22 in. (560 mm) diameter and bolt square of 15 1/2 in. (394 mm).

1240 *Four high strength steel anchor bolts, 2 1/4 in. (57 mm) in diameter and 96 in. (2,400 mm) long, including the hook, shall be furnished with each pole. Each bolt shall have 2 hex nuts and 2 washers in accordance with ASTM A 307, grade A. The anchor bolt material shall be in accordance with ASTM A 576 or ASTM A 675 (A 675M) with a minimum yield strength of 55,000 psi (379 MPa) or ASTM A 36 (A 36M), special quality, modified to 55,000 psi (379 MPa) or approved equal. The threaded end of the anchor bolt shall have 12 in. (305 mm) of 4 1/2 NC threads and shall be galvanized the length of the threads, plus 3 in. (75 mm). The threaded end shall be coated after fabrication in accordance with ASTM A 153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. The unthreaded end of the anchor bolt shall have a standard L bend for a distance of 9 in. (230 mm) from the centerline of the anchor bolt to the end of the L. In lieu of the standard bend a steel plate 4 1/2 sq in. (2,900 mm²) and 1 1/4 in. (32 mm) thick may be welded to the embedded end of the anchor bolt.*

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(b) Wood Strain Pole

Wood strain poles shall be made from southern yellow pine and shall be in accordance with the current ANSI Specifications and Dimensions for Wood Poles No. 05.1. They shall be of the length and class specified.

All poles shall be full length pressure treated by the full cell process in accordance with current specifications as set forth in the AWPAs Standards C1 and C4, using preservative as outlined in standard P5 and set forth in 911.02(h).

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Treatment, handling, and storage methods shall be in accordance with the current AWPAs Standards.

(c) Signal Cantilever Structures

1. General

All traffic signal cantilever structures, with or without combination arm, shall be as shown on the plans.

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There shall be no threads in the wearing surface plane at the point of connection between the clevis clamp and the signal face assembly. The clevis clamp shall have an 11/16 in. (18 mm) diameter bolt hole to receive the signal face assembly.

The signal cantilever structure pole, sections 1 and 2, signal arm, and combination arm shall be a round or multi-sided tapered tube, except the upper 4 to 6 ft (1.2 to 1.8 m) of a signal pole may be non-tapered. The pole and arms taper rate shall be 0.14 in./ft (12 mm/m). The signal cantilever structure poles shall have a reinforced handhole as shown on the plans. A 1/2 in. (13 mm) 13 NC threaded grounding nut or approved equivalent shall be provided and be accessible through the handhole. The pole cap shall be secured in place with setscrews. The pole shall be provided with a removable pole cap and integral wire support hook for the luminaire electrical cable. The cable shall be attached to the hook by a service drop clamp.

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The signal cantilever arm and combination arm, if required, shall be attached to the pole as shown on the plans. The arms shall have cable inlets as shown on the plans. All signal heads on the arm shall be attached as shown on the plans and installed parallel to the horizontal plane and centered to the cantilever arm. The cantilever arms shall be used as an enclosed raceway for wiring and shall be free of burrs or rough edges.

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The pole top luminaire for roadway lighting, if required, shall be installed on these structures as shown on the plans.

2. Base Plate

A one piece anchor base shall be supplied as shown on the plans. Four removable bolt covers shall be provided with each base and each cover shall attach to the upright portion of the body of the base by means of 1 hex head cap screw.

3. Materials

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The signal cantilever pole, arms, base plates, arm flange plates, gusset plates, ring stiffeners, and pole splice plates shall be in accordance with ASTM A 595 or A 572 with a minimum yield strength of 50,000 psi (345 MPa).

4. Hardware

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Bolts for the pole splice shall be in accordance with ASTM A 490 and shall be galvanized. The contact area for both pole splice plates shall be class B in accordance with AASHTO 10.32.3c with a minimum slip coefficient of 0.5. The surfaces shall be blast cleaned with class B coatings. The arm flange plate connection bolts shall be in accordance with ASTM A 325. All other hardware shall be in accordance with ASTM A 307 and galvanized in accordance with ASTM A 153, or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM A 153, class C. A cast pole cap shall be in accordance with ASTM A 126 and shall be galvanized with a minimum coating of 2 oz/sq ft (0.610 kg/m²).

5. Anchor Bolts

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Four steel anchor bolts, each fitted with 2 hex nuts and 2 flat washers, shall be furnished with each pole. The anchor bolt shall be as shown on the plans with a minimum of 15 in. (380 mm) of 7 NC threads on the upper end. The threads, nuts, and washers shall be galvanized in accordance with ASTM A 153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A 153. The steel for the bolt shall be in accordance with ASTM F 1554, with a yield strength of 36,000 psi (248 MPa) or 55,000 psi (379 MPa), or approved equal.

6. Finish

All steel material shall be fully galvanized. Galvanizing shall take place after all welding is accomplished and holes cut.

7. Certification

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Unless otherwise specified, all materials covered herein shall be covered by a type C certification in accordance with 916.

8. Working Drawings

Working drawings and design calculations shall be submitted in accordance with 105.02.

(d) Downguys, Anchors, Rods, and Guards

1340 *Pole anchors shall be 8 way expanding with a minimum area of 135 sq in. (87,100 mm²) when expanded or a 10 in. (250 mm) diameter screw anchor. They shall have a minimum holding strength of 10,000 lb (44.5 kN). They shall be painted and in accordance with ASTM A 569 (A 569M). Anchor rods for expanded anchors shall be 3/4 in. (19 mm) diameter steel and for screw anchors shall be 1 1/4 in. (32 mm) diameter steel, 8 ft (2.4 m) long, in accordance with ASTM A 659 (A 659M), and be galvanized in accordance with ASTM A 153.*

1350 *Guy guards shall be made of 18 gauge galvanized steel, polyethylene, polyvinylchloride, or melamine phenolic, and shall be 7 ft (2.1 m) long. The steel guy guard shall have a tight gripping, non-scarring hook for quick attachment to the guy wire. The bottom shall have a clamp that fits over the anchor rod and securely grips by tightening the bolt. Steel guy guards shall be in accordance with ASTM A 659 (A 659M). The nonmetallic guy guard shall be a helical pigtail which shall resist upward movement, a lock strap to secure the lower end, and a guy guard sleeve. Non-metallic guy guards shall be gray or yellow.*

(e) Support Cable

1. Messenger Cable

1360 *Messenger cable shall be zinc-coated steel wire strand, contain 7 wires, and have a nominal diameter of 3/8 in. (10 mm). The cable shall be in accordance with ASTM A 475, Siemens-Martin Grade.*

2. Span, Catenary, and Downguy Cable

Span, catenary, and downguy cable, shall be aircraft cable for non-aircraft use, and shall be 3/8 in. (10 mm) nominal diameter, made of stainless steel wire, and consist of 7, 19 wire flexible steel strands. The 3/8 in. (10 mm) cable shall have a minimum breaking strength of 12,000 lbs (53.4 kN). It shall be in accordance with Military Specifications MIL-W-83420D.

3. Tether and Support Cable

1370 *Tether and support cable shall be aircraft cable, for non-aircraft use, and shall be 3/16 in. (5 mm) nominal diameter, made of stainless steel wire, and consist of 7, 7-wire flexible steel strands. The 3/16 in. (5 mm) cable shall have a minimum breaking strength of 3,700 lbs (16.5 kN). It shall be in accordance with Military Specifications MIL-83420D.*

4. Cable Hardware

(a) Messenger Hangers

Messenger hangers shall be either a 3-bolt clamp or a 3/8 by 1 3/4 in. (10 by 44 mm) steel hanger with a 90° bend extending from the pole 3 3/4 in. (95 mm). The hanger

- 1380 shall have a curved groove and clamp capable of receiving a 5/16 to 1/2 in. (8 to 13 mm) cable.

The messenger shall be clamped by two 1/2 in. (13 mm) high carbon steel bolts. The angle hanger shall be mounted with a 5/8 in. (16 mm) through bolt and a 1/2 in. (13 mm) lag screw. The 3-bolt clamp shall be mounted with a 5/8 in. (16 mm) through bolt. The angle hanger shall be in accordance with ASTM A 575. The bolts shall be in accordance with NEMA PH 23.

(b) Cable Ring

- 1390 Cable rings shall be galvanized steel in accordance with IMSA 51-1.

(c) Clamps

Clamps shall be made of 3/8 in. (10 mm) steel and in accordance with ASTM A 575.

Two bolt clamps shall be a minimum of 3 3/4 in. (95 mm) long and 1 1/4 in. (32 mm) wide with two 1/2 in. (13 mm) bolts which shall clamp cable of 1/8 to 1/2 in. (3 to 13 mm) diameter.

- 1400 Three bolt clamps shall be a minimum of 6 in. (150 mm) long and 1 5/8 in. (42 mm) wide with three 5/8 in. (16 mm) bolts which shall clamp cable of 5/16 to 1/2 in. (8 to 13 mm) diameter.

The bolt heads shall be large enough to provide maximum clamping area and shall have oval shoulders to prevent the bolts from turning while tightening. The bolts shall be in accordance with NEMA PH 23.

(d) Servi-Sleeves

- 1410 Servi-sleeves shall be 1 1/4 to 2 1/4 in. (32 to 57 mm) in length and shall hold the size of the cable specified. The sleeves shall be in accordance with ASTM A 659 (A 659M).

(e) Straight Eye-Bolts

Straight eye-bolts shall be 3/4 in. (19 mm) diameter drop forged steel, a minimum of 14 in. (356 mm) long, and have 6 in. (150 mm) of thread. The steel washers shall be 2 1/4 by 2 1/4 by 3/16 in. (57 by 57 by 5 mm) in size with a 13/16 in. (21 mm) hole in the center. All parts shall be in accordance with ASTM A 575 and shall be galvanized in accordance with ASTM A 123.

- 1420 **(f) Hub-Eyes**

Hub-eyes shall be made of drop forged steel and in accordance with ASTM A 575. They shall receive a 3/4 in. (19 mm) mounting bolt and have a full rounded thimble eye for protection of the guy cable.

922.11 Signal Cable

(a) Hook-up Wire

1430 *Signal hook-up wire shall be stranded 1 conductor wire, type THW 7 strand No. 14 AWG, with a thermoplastic sheath 3/64 in. (1.19 mm) thick and a 600 volt rating. Insulation shall be color coded, as required, and labeled with gauge, voltage rating, and insulation type.*

(b) Signal Control Cable

Signal control cable shall be in accordance with IMSA 19-1 or 20-1 and shall be stranded No. 14 AWG wire.

(c) Service Cable

1440 *Traffic signal service cable shall be color coded, stranded copper No. 8 AWG wire, 3 conductor cable, type THWN.*

922.12 Signal Interconnect

(a) Integral Messenger Interconnect Cable

Integral aerial interconnect cable shall be figure "8" self-supporting type cable consisting of a messenger cable and 7 conductors No. 14 AWG signal cable in accordance with IMSA 20-3.

(b) 6 Pair/19 Telemetry Cable

1450 *6 pair telemetry cable shall contain 6 twisted pairs of 19 gauge conductors and shall be in accordance with IMSA 40-2 for underground application and IMSA 40-4, integral messenger, for aerial application.*

(c) Fiber Optic Interconnect Cable

Fiber optic cable shall contain 6 stranded multimode, graded index, optic fibers with a minimum of 1 non-metallic central strength member. The cable shall be loose tube, all dielectric construction, suitable for outdoor use in conduit or on aerial supports.

1460 *Each individual fiber shall be 62.5/125 μm diameter, core/clad, and each fiber shall be individually encased in its own gel-filled color-coded buffer. The fiber optic cable shall be constructed with Kevlar braid and outer polyethylene jackets as a minimum. If an inner jacket is used it shall be PVC. Maximum attenuation of the cable shall be 4.0 dB/km nominal, measured at room temperature at 850 nm. The bandwidth shall not be less than 160 MHz/km, also at 850 nm. Each fiber shall be continuous with no factory splices except for joining standard length cables to form longer, continuous jacketed cable to fit installation requirements. The cable shall have standard nylon rip cords. Kevlar rip cords will not be accepted. The cable shall be in accordance with the generic requirements for optical fiber and optical fiber cable per Bellcore Technical Reference TR-TSY-000020.*

1470 *The exterior of the polyethylene outer cable jacket shall be stenciled so that every fifth meter on each reel is marked with a number. The fifth meter of each reel shall be marked with a 5, the tenth meter marked with a 10, and so on until the end of the reel. The stencil shall be applied to the outer jacket using permanent ink and shall be permanently engraved into the jacket to provide long lasting readability.*

922.13 Detection Components

(a) Loop Detector Lead-in Cable

1480 *Runs 700 ft (213 m) and less of loop detector lead-in cable shall be in accordance with IMSA 50-2 and shall be stranded 2 conductor No. 16 AWG, 19 strands of No. 29 wire. Runs greater than 700 ft (213 m) shall use 14 AWG wire.*

The nominal capacitance between conductors shall be 57 pF/ft (187 pF/m) and 98 pF/ft (322 pF/m) between one conductor and the other conductor connected to the shield.

(b) Roadway Loop Wire

Roadway loop wire shall be 14 AWG gauge IMSA 51-7 duct-loop wire with polyvinyl chloride or polyethylene outer jacket of 1/4 in. (6.3 mm) diameter.

(c) Preformed Pavement Loops

1490 *All components of preformed pavement loops designed for HMA paved-over application shall have a minimum temperature rating of 300°F (150°C). Preformed pavement loops shall be selected from the Department's list of approved Traffic Signal and ITS Control Equipment.*

The size of a preformed pavement loop shall be 6 ft (1.83 m) diameter, 18.9 ft (5.75 m) circumference round or 6 ft (1.83 m) octagonal, 20 ft (6.1 m) perimeter. The loops placed in the same lane shall be spaced 15 ft (4.57 m) from the center of one loop to the center of the next loop.

1500 *Preformed pavement loops may be constructed as a single loop or as 2, 3 or 4 loops in series. Each individual loop shall be wired with 4 turns of wire unless otherwise specified. Loops constructed in a series shall also be wired in series.*

(d) Microloop Detectors

Materials for microloop detectors shall be selected from the Department's approved materials list. The microloop detectors selected shall be capable of counting vehicles in addition to detecting vehicle presence.

1510 *Each microloop detector location shall include the following items:*

1. *Non-invasive probe, lead-in cable and carriers for microloop detector as shown on the plans;*
2. *3-in. diameter schedule 80 PVC conduit containing the probes, lead-in cable and carriers;*
3. *Buried service wire encapsulation kit compatible with microloop detector for all splicing between the lead-in cable and the home run cable;*
4. *Installation kit, one for each conduit containing probes;*

1520

5. All mounting hardware, conduit bushings, wiring, connectors, grounding wires, ground rods, grounding cables, etc., necessary to complete the microloop detector location installation.

922.14 Ground Wire

1530 The ground wire shall be copper wire No. 6, AWG soft-drawn, solid copper in accordance with ASTM B 3.

922.15 Splicing Kit

Splicing kits shall contain a 2 piece, transparent snap-together mold body and include an epoxy and sealing compound contained in a unipak. It shall be capable of insulating and splicing nonshielded cables rated up to 5 kilovolts and multi-conductor cables rated up to 600 volts.

922.16 Ground Rod and Connections

1540 Ground rods shall be 1/2 in. (13 mm) in diameter by 8 ft (2.4 m) long with a machined point and chamfered top. They shall be made of steel with a molecularly bonded outer layer of electrolytically applied copper. A single electrode shall have a maximum resistance to ground of 25 ohms. Single electrodes that do not have resistance to ground of 25 ohms or less shall be augmented by additional electrodes, grids, or plates until resistance to ground of 25 ohms or less is achieved. Resistance shall be measured using a 3-point ground tester using the fall of potential method. Data, graphs, resistance in ohms, date of test, make and model of ground tester, and the individual's initials performing the test shall be recorded and submitted to the District Office. Resistance in ohms shall be tagged at the ground connection.

1550 The finished rod shall be cold-drawn and shall have the following minimum physical properties:

PHYSICAL PROPERTY	MINIMUM
Tensile strength	97,000 psi (668 MPa)
Yield strength, 0.2% offset	85,000 psi (586 MPa)
% of elongation	13 psi (90 kPa)

The ground rod and wire connection shall be made by a thermo weld process or approved equal. The welding material shall cover and secure the conductor to the rod and shall be porous free.

1560 An acceptable alternate shall be a ground grid connection properly sized and shall consist of a shear head bolt, a "C" shaped body, nest, and wedge. The connector components shall be fabricated from an aluminum-bronze alloy, silicone-bronze alloy, and copper.

922.17 Castings for Handholes

The ring and cover for handholes shall be in accordance with 910.05(b).

922.18 Entrance Switch

1570 *The entrance switch shall be a double pole, 50 A, 120V AC circuit breaker in a NEMA type 3R enclosure. The minimum dimensions of the enclosure shall be: 5 in. (127 mm) wide, 3 3/4 in. (95 mm) deep and 9 1/4 in. (235 mm) height. A 1 in. (25 mm) rain-tight detachable hub shall be supplied in the top of the enclosure. The enclosure shall have knockouts on the sides, bottom and back with diameters of 7/8 in. (22 mm) to 1 3/4 in. (44 mm). The enclosure shall contain the circuit breaker, an insulated solid bar for connection of AC neutral, a separate lug for attachment of earthground, have provisions for a padlock, and shall be surface mounted.*

The enclosure shall be made of galvanized steel with a rust inhibiting treatment and finished in the manufacturer's standard color of baked enamel.

1580 *All wire terminations and breaker to buss-bar contact points inside the enclosure shall be coated with an anti-oxidant to prevent oxidizing and corrosion of components.*

922.19 Conduit and Fittings

(a) Steel Conduit

1590 *Steel conduit, couplings, and elbows shall be galvanized rigid steel conduit in accordance with UL 6. The conduit shall be galvanized by the hot dip method on the interior and exterior surfaces. Conduit threads shall be cut after galvanizing. The conduit shall be supplied with a threaded coupling attached to one end and the other threaded end protected by a suitable shield.*

The various conduit fittings such as bands, bodies, straps, lock nuts, and threadless connectors, shall be in accordance with Federal Specifications A-A-50553 and shall be galvanized if not stainless steel. Conduit straps shall be 2 hole straps with a minimum thickness of 1/8 in. (3 mm). Conduit lock nuts 3/8 to 1 1/2 in. (10 to 38 mm) in size shall be made of steel. Other sizes shall be made of either steel or malleable iron. All conduit lock nuts shall be galvanized. Other nuts shall be either stainless steel or galvanized steel.

(b) Polyvinyl Chloride, PVC, Schedule 40 or 80 Conduit

1600 *Conduit, fittings, and accessories shall be manufactured from polyvinyl chloride meeting ASTM D 1784 and shall comply with all the applicable requirements of NEMA TC2 and UL 651. Each length of pipe shall include tracer wire and a coupling.*

(c) Fiberglass Conduit

1610 *Rigid fiberglass conduit and fittings shall be filament wound consisting of E-glass and corrosion resistant epoxy resin manufactured for use at temperatures from -40 to 230°F (-40 to 110°C). Rigid fiberglass conduit shall be pigmented with carbon black for ultraviolet protection and fire resistant per UL 94. All rigid fiberglass conduit shall have tracer wire, be heavy walled, HW, and meet the specifications, labeling and testing of ANSI/NEMA TC14.*

922.20 Detector Housing

The entire housing casting shall be made from aluminum alloy in accordance with ANSI 320.

922.21 Certification

Unless otherwise specified, all materials covered herein shall have a type C certification in accordance with 916.

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