TRAFFIC SIGNAL CONSTRUCTION AND INSPECTION IN PENNSYLVANIA

pennsylvania
DEPARTMENT OF TRANSPORTATION

Highway Administration Deputate

There are hyperlinks throughout this document that should provide network connections to other publications, regulations, Vehicle Code, etc. There are also hyperlinks that reference other sections, exhibits, or appendices within the same chapter, and these should assist you in navigating within the manual.

Although not obvious by their color, the Table of Contents and the List of Exhibits within the individual chapters also work as hyperlinks. Simply left click on the section or exhibit number, title, or page number and your computer should take you to the proper page.

You may also find the bookmarks on the left side of the screen helpful.

This training course was developed in partnership with the Pennsylvania Department of Transportation's Business Leadership and Administrative Services Office and the Highway Safety and Traffic Operations Division, and Albeck + Associates, Inc. It is offered as part of the Pennsylvania Department of Transportation's Highway Administration Comprehensive Training Plan exclusively through the Technical Training and Development Section.

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CHAPTER 1. INTRODUCTION

1.1 Introduction

This training manual was written for individuals who are involved in the construction and inspection of traffic signals in the Commonwealth of Pennsylvania. The manual was produced by the Pennsylvania Department of Transportation's Business Leadership and Administrative Services Office and the Highway Safety and Traffic Operations Division with technical assistance from other PennDOT units.

The objective of this training manual is to provide an overview of the contract documents and to review PennDOT's materials and construction requirements for these projects. It is designed to assist everyone involved in these projects in becoming familiar with the contract documents, construction requirements and their application to projects so the location and installation of contract items on all projects is uniform and as maintenance free as possible.

Neither this manual nor the training is intended as substitutes for actual contract documents.

1.2 General

Traffic signal projects must comply with the applicable traffic signal construction documents (specifications, plans, standard drawings, etc.). Inferior work on signals or inadequate traffic management during project construction can create potentially dangerous conditions with liability impacts for local agencies.

The purpose of this course and manual are to provide an introduction to traffic signal construction and inspection issues, including a discussion of important reference documents and technical certifications for traffic signal inspections.

This course is only one-day in length. The breadth of this topic cannot be fully addressed in a single day. The course will be converted into an e-learning course that will include details not fully covered in the one-day instructor led session.

1.3 Manual Layout

This Traffic Signal Construction and Inspection course manual includes the following chapters:

- ✓ Chapter 1 is this introduction
- ✓ **Chapter 2** discusses some of the publications and forms applicable to traffic signal construction and inspection
- ✓ **Chapter 3** focuses on the traffic signal plan and other contract documents
- ✓ **Chapter 4** is a summary of some of the materials used for traffic signal projects
- ✓ **Chapter 5** is an overview of the traffic signal construction process
- ✓ **Chapter 6** covers traffic signal inspection

This manual references numerous traffic signal publications covered in Chapter 4.

It is important to note, the publications, forms and documents referenced in this training manual can be, and are, updated at some point in the future. The holder of this manual is responsible to check the source material to ensure they are using the most up-to-date information. The latest version of the documents can be found on the traffic signal portal (see Section 1.5).

1.4 Goals of the Course

At the end of this Traffic Signal Construction and Inspection in Pennsylvania course, you are able to:

- ✓ Locate applicable traffic signal catalog cuts
- ✓ Describe the applicable traffic signal proprietary approvals
- ✓ List the traffic signal product approvals process
- ✓ List the important sections of Publication 408 (Specifications) and its requirements
- ✓ Understand and navigate Publication 669 (Traffic Signal Inspection Pocket Guide)
- ✓ Traffic signal testing procedures
- ✓ Develop and modify a traffic signal inspection Form

1.5 Traffic Signal Portal Website

The Department's Traffic Signal Portal can be found at:

www.dot.state.pa.us/Portal%20Information/Traffic%20Signal%20Portal/Index.html

Exhibit 1-1 PennDOT Traffic Signal Resource Portal

The portal serves as a central location for information on traffic signals in Pennsylvania. It includes, but is not limited, to the following sources:

- ✓ Publications, policies, forms, and other documents
- ✓ Approved products listing
- ✓ Frequently asked questions
- ✓ Traffic signal processes and procedures
- ✓ Automated red light enforcement (ARLE)
- ✓ Mapping and spreadsheets
- ✓ Training updates
- ✓ Traffic signal performance measures
- ✓ Recent news

1.6 Responsibilities of the Inspector

Some of the inspector's responsibilities include, but are not limited to, the following:

- ✓ Work with the contractor to ensure construction of the traffic signal installation is completed safely with proper protection of the contractor's employees, the traveling public and pedestrians in, or adjacent to, the work area.
- ✓ Verify the items of work are done in accordance with the special provisions, the plans, standard drawings, and in conformance with industry standards.
- ✓ Know the status of, and be involved in, coordination of the work and with the utilities that affect the progress of the work.
- ✓ For Department projects, coordinate with the District Traffic Unit if changes in the location of an item have a potential effect on the structural requirements of traffic signal supports, the visibility of the traffic signals and/or the operation of the vehicle detection.
- ✓ For Highway Occupancy Permit (HOP) projects, coordinate with the municipality if changes in the location of an item have a potential effect on the structural requirements of traffic signal supports, the visibility of the traffic signals and/or the operation of the vehicle detection.
- ✓ Prior to the "turn-on" of new or revised traffic signals, verify, in conjunction with the District Traffic Unit, vehicle detection setup and controller operation, field testing and programming.
- ✓ Monitor and record any changes to the design plans so you can verify the contractor's as-built (record) plans.
- ✓ Verify that all materials installed are on the approved CS-201 (see Section **2.12**).

As noted in Publication 408 (Standard Specifications), Section 105.11:

DUTIES OF THE INSPECTOR - Authorized inspectors, who perform their duties under the direction of the Representative, will be assigned to the project.

Execute work under the observation and subject to examination of an inspector(s); carry out such work during the normal working hours of the day, unless specifically directed otherwise. If work is performed during nighttime hours with permission, provide sufficient artificial lighting to assure proper inspection and workmanship.

The inspector is not authorized to do the following: revoke, alter, enlarge, relax, or release any requirements of the specifications; approve or accept any portion of the work; or issue instructions contrary to the plans and specifications.

The presence of the inspector during the performance of any work on the project will not relieve the Contractor of the responsibility for work that is later determined by the Representative to be defective.

1.7 Responsibilities of the Contractor

Publication 408 (Standard Specifications), Section 105.05 indicates:

RESPONSIBILITY OF CONTRACTOR—

(a) **General**. Keep direct control of the contract and see that the work is properly supervised and is performed satisfactorily and efficiently. Supervise the work personally or appoint a competent superintendent or representative to be on the project at all times. Give this superintendent or representative the authority to receive orders and directions; to execute orders and directions without delay; and to make arrangements for all necessary material, equipment, and labor.

Keep on the project, at all times, a copy of the plans, a copy of the specifications, and a copy of the contract, and a copy of all subcontracts.

The Department is not responsible for the Contractor's satisfactory completion of the contract work as a consequence of the presence of Department representatives or inspectors and their inspection.

(b) **Work By Others**. For work to be done without the supervision of the Department, investigate the work and anticipate its execution and completion. The Department will not be liable for failure to anticipate the time of performance and completion of such work, except in those cases where, upon timely request, the Department has agreed to cooperate.

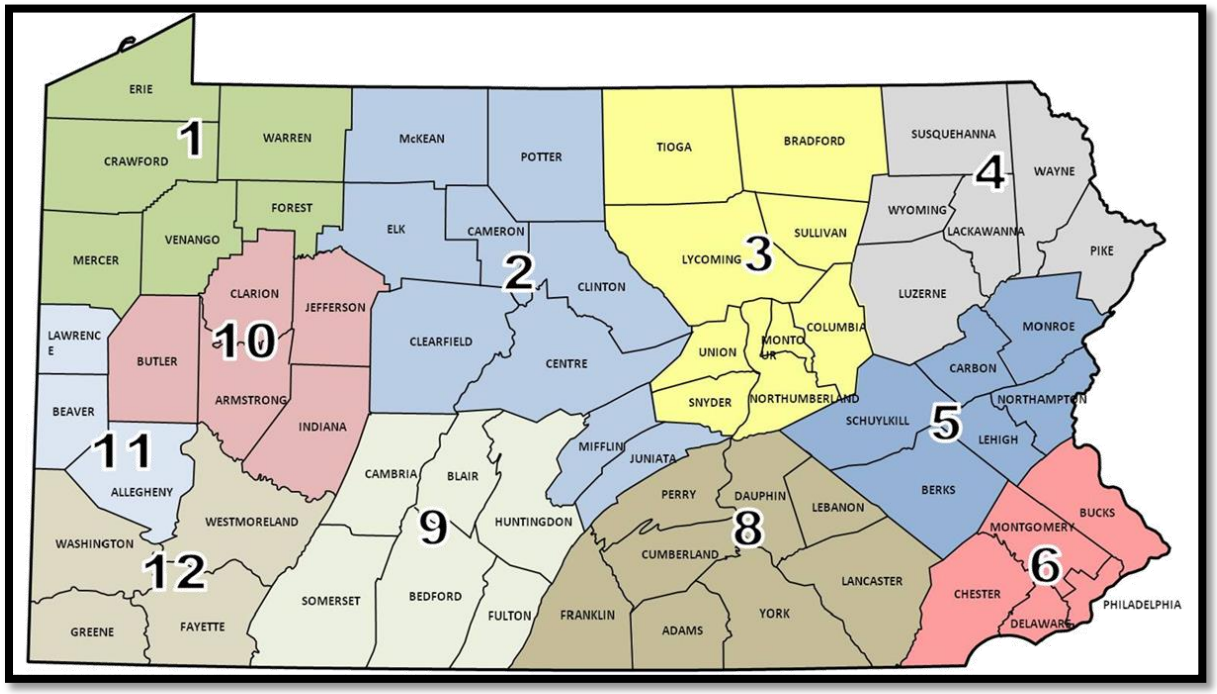
(c) **Gratuities and Penalties**. Do not give or offer, or allow agents, employees, or representatives to give or offer, either directly or indirectly, money, property, entertainment, or other valuable things, to any employee or representative of the Department for any reason, purpose, or cause, or as an inducement, bribe, or reward for doing or omitting to do any act, or for showing any favor or disfavor in relation to any matter relating to the contract. Any such action will constitute a violation of the contract. Upon satisfactory proof to the Secretary of such violation, the Department may terminate performance of the work and take steps to complete the project, as specified in Section 108.08 of Publication 408.

1.8 Responsibilities of the District Traffic Unit

For traffic signal construction projects, some of the responsibilities of the District Traffic Unit include, but are not limited to, the following:

- ✓ For Department projects, provide design and technical operation support to the inspector.
- ✓ For Department projects, provide technical assistance to the Inspector when field conditions require any changes to the plan.
- ✓ Work closely with the inspector if it is necessary to instruct the traffic signal contractor. Since instructions to the contractor may be construed as authorized additional work and he may make a claim, it is imperative that all instructions be closely coordinated with the field personnel. If something is observed that is not in accordance with the permit, specifications and/or standards, it is permissible to inform the contractor of the condition.
- ✓ Prior to the "turn-on" of new or revised traffic signals, verify, in conjunction with the inspector, vehicle detection setup and controller operation, field testing and programming.
- ✓ Monitor and be available for questions and problems during the 30-day test period. Monitor final acceptance of the signals.
- ✓ Promptly review materials submitted on CS-201 (see Section **2.12**).

1.9 District Contacts



District	Current Contact Name	Email	Contact Number
1	Susan Roach	sroach@pa.gov	(814) 678-7177
2	Dennis Prestash	dprestash@pa.gov	(814) 765-0402
3	Lara Lapinski	llapinski@pa.gov	(570) 368-4250
4	Thomas Pichiarella	tpichiarel@pa.gov	(570) 963-3187
5	Christopher Surovy	csurovy@pa.gov	(610) 871-4478
6	Ashwin Patel	ashpatel@pa.gov	(610) 205-6567
8	Eric Kinard	ekinard@pa.gov	(717) 787-9237
9	Tony Tanzi	ttanzi@pa.gov	(814) 678-7177
10	Melissa McFeaters	mmcfeaters@pa.gov	(724) 357-2844
11	Ed Miller	edmille@pa.gov	(412) 429-4970
12	Nancy Kolenc	nkolenc@pa.gov	(724) 439-7268
Central Office	Daniel Farley	dfarley@pa.gov	(717) 783-0333

The above contact names are current at the time of printing but are subject to change.

1.10 Glossary of Terms and Abbreviations

Not all of the terms shown on the following table are used in this manual. They are included as a resource to the holder of the manual.

Term	Definition
85th Percentile Speed	This is the speed at which 85% of the traffic is travelling at or below.
AASHTO	The American Association of State Highway and Transportation Officials
Actuated Operation	A type of traffic control signal operation in which some or all signal phases are operated on the basis of actuation (vehicle detection, pushbutton, etc.).
Actuation	The presence of a vehicle or pedestrian as indicated by an input to the controller from a detector. The action of a vehicle or pedestrian which causes a detector to generate a call to the signal controller.
ADA	Americans with Disabilities Act (1990)
Adaptive Traffic Control	A software program that is designed to adjust the signal timing to accommodate changing traffic patterns and ease traffic congestion. By receiving and processing data from sensors to optimize and update signal timing settings, adaptive signal control technologies can determine when and how long lights should be green.
All-Red	An interval during which all signal indications at an intersection display red indications.
Approach	All lanes of traffic that enter the intersection from the same direction.
As-Built (or Record) Plans	A modified traffic signal plan showing the roadway geometrics and the traffic signals after completion of the construction project, and showing any field adjustments due to structural shifts of signal supports, unanticipated corner radius changes, etc.
Annual Average Daily Traffic (AADT)	The total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is.
Average Daily Traffic (ADT)	The total volume of vehicle traffic of a highway or road for a period of time less than 1-year divided by the number of days of the count.
Call	A demand for service registered in a controller. A call indicates a vehicle or pedestrian is waiting for a green light or walk indication.
Clearance Interval(s)	The interval(s) from the end of the right-of-way of one phase to the beginning of a conflicting phase. This is usually the yellow plus any all-red phase.

Term	Definition
Conflict Monitor	A device housed in the controller cabinet which continuously checks for the presence of conflicting signal indications such as simultaneous green signal indications on both the mainline and side road approaches. If a conflict is detected, the monitor places the signals into a flashing operation.
Controller	The electronic device that controls the sequence and duration of traffic signal indications.
Cycle Length	The time taken for a complete sequence of all phases at an intersection. This time is counted from a given point on any phase (usually main street end of green) until that same point occurs again. Pretimed cycle lengths do not vary, but actuated cycle lengths do because of phases skipped, extensions, etc.
Delay	Time lost while traffic impeded in its movement by some element over which it has no control. Usually expressed in seconds per vehicle.
Department	Term used to reference the Pennsylvania Department of Transportation.
Design Modifications	A proposed change to the approved design and operation of an existing traffic signal or signal system to accommodate changes in prevailing traffic or physical conditions, or to update the installation to current state-of-the-art design. Typical modifications include addition or removal of signal phases or special functions; changes in signal displays, configurations, or locations; detector modifications; upgrading of equipment and communication systems; and revisions to related signs and pavement markings. These changes can be initiated by any involved party, but cannot be physically implemented until the signal permit is updated.
Detector	A device that provides an input to the controller to indicate that a vehicle or pedestrian is present.
Documentation	The information for the traffic signal or signal system, including the traffic signal permit, equipment manuals and warrantees, summary and detailed listing of all signal maintenance, and design modifications, etc.
Free Flow	Traffic flow which is not impeded.
Full Traffic-Actuated Controller Unit	A type of traffic-actuated controller unit which accommodates for traffic actuation on all approaches to the intersection.
Gap (Time Gap)	The interval in time or distance from the back of one vehicle to the front of the following vehicle.
Green Interval	The right-of-way portion of a traffic phase.

Term	Definition
Headway	The distance or (usually) time between vehicles measured from the front of one vehicle to the front of the next.
HDPE	High-Density Polyethylene Conduit
HOP	Highway Occupancy Permit
Incandescent Indications	Vehicular or pedestrian signals, or a blank-out sign, that are illuminated with a traditional light bulb having a thin tungsten filament.
Infrared Detection	An overhead mounted device that illuminates a select area with low-power infrared energy supplied by light-emitting diodes (LEDs) or laser diodes, and then converts the reflected energy into an electrical signal to indicate the presence of a vehicle or person. Infrared detectors may have special applications for detecting pedestrians and bicyclists.
Intersection	The area embraced between the prolongation and connection of the lateral curb lines, or if none, the lateral boundary lines of the roadways (i.e., the traveled portion) of two or more streets or highways.
Intersection Leg	The roadways entering or leaving one side of the intersection.
Interval	Any one of the several divisions of the cycle during which signal indications do not change.
Interval Sequence	The order of appearance of signal indications during successive intervals of a cycle.
Isolated Controller Unit Operation	The operation of a controller unit at an intersection without master controller supervision dial-up communication.
Isolated Intersection	A signalized intersection that is located far enough from other signalized intersections so that the signal timing at the other intersections does not influence the traffic flow at this intersection.
Local Authorities	Definition from Section 212.1 of Title 67 of the Pennsylvania Code. i. County, municipal and other local boards or bodies having authority to enact regulations relating to traffic. ii. The term also includes airport authorities except where those authorities are within counties of the first class or counties of the second class. iii. The term also includes state agencies, boards and commissions other than the Department, and governing bodies of colleges, universities, public and private schools, public and historical parks.

Term	Definition
Local Controller	The controller located at an intersection and which operates the traffic signals only at that intersection, and does not control or directly influence any other intersection.
Loop Detectors	A commonly used device to monitor traffic on the approach to a traffic control signal, consisting of multiple circles of wire in a basic square or rectangular shape that is buried within the roadway and which detects changes in their magnetic field caused by the metal in passing vehicles.
Maintenance Service Manuals	The document provided by the manufacturer of a piece of equipment that specifies how to adjust, clean, lubricate, calibrate, and otherwise maintain the equipment to ensure its proper operation and its longevity.
Maintenance Service Records	An accumulation of paperwork that captures all service performed to the traffic signals at a specific intersection. This paperwork identifies all inspections, cleaning, tightening, calibrations, adjustments, replacements, lubrications, etc., that were performed from either a preventative view point, or repairs due to crashes or equipment failure.
Malfunction Management Unit (MMU)	The malfunction management unit (MMU) can be configured to check for conflicting signal indications and various other malfunctions including absence of an OK status output from the controller (watchdog output), short or missing clearance intervals, and out-of-range operating voltages. If a malfunction is detected, the MMU automatically places the signal in an all-red flashing state, overriding the outputs of the controller.
Master Controller	The controller that supervises and directs the timing patterns for all local controllers within a traffic control signal system for the purpose of coordinating the operation of the signal system to improve traffic flow and safety.
Maximum Green	A longest period of green time allowed when there is a demand on an opposing phase.
Median Refuge	Raised islands or medians of sufficient width that are placed in the center area of a street or highway to serve as a place of refuge for pedestrians who are attempting to cross. Center islands or medians allow pedestrians to find an adequate gap in one direction of traffic at a time, as the pedestrians are able to stop, if necessary, in the center island or median area and wait for an adequate gap in the other direction of traffic before crossing the second half of the street or highway.

Term	Definition
Microwave Detection	Equipment that transmits an electromagnetic signal and compares the reflected signal from all objects in the protected area by use of the Doppler Effect. Based on a selected sensitivity level, it determines if the detection criteria are met; and if so, advises the controller of the presence of traffic.
Minimum Green	The shortest green time allowed in a phase.
MUTCD	Manual on Uniform Traffic Control Devices
Offset	The relationship in time between a point in the cycle at a particular intersection and a similar point in the cycle at another intersection or reference.
NTCIP	National Transportation Communications for ITS Protocol
Operations	As it relates to traffic, this is the day-to-day control of traffic systems, including the analysis of the systems, detection of problems and deficiencies, setting of priorities, assignment of resources, and development of improvements through geometric design, traffic control, or other means. Frequently referred to as “traffic operations.”
Passage Period	The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic, i.e., from the detector into the intersection.
Pedestrian "WALK" Interval	The controller interval during which the "WALK,” symbolized by the "WALKING PERSON,” indications of the pedestrian signals are illuminated.
Pedestrian Clearance Interval	The first clearance interval following the pedestrian walk interval, normally symbolized by the flashing "HAND.” The pedestrian clearance interval shall allow a pedestrian, who has already begun to cross, time to reach the far side of the roadway or a safe refuge. A pedestrian shall not begin to cross during this interval.
Pedestrian Detection	Hardware used to notify the traffic controller of the presence of a pedestrian, typically via a pushbutton.
Pedestrian Phase	A traffic phase allocated exclusively to pedestrian traffic.
Pedestrian Signal Indication	The illumination of a pedestrian signal lens or equivalent device.
Phase	The part of a cycle allocated to any combination of traffic movements receiving the right-of-way simultaneously during one or more intervals, i.e., for example a left turn phase.
Preemption	The transfer of the normal control of signals to a special signal control mode, i.e., to accommodate emergency vehicles.

Term	Definition
Pre-Timed Controller Operation	A method for operating traffic signals where the cycle length, phases, green times, and change intervals are all preset.
Preventative (Routine) Maintenance	Maintenance scheduled on a regular basis to minimize future maintenance and to maximize the life of the equipment. It includes inspection, calibration, cleaning, testing, sealing, painting, etc., in accordance with a predefined schedule. This maintenance is similar to the maintenance schedule for a vehicle.
Publication 111M	The Department's Traffic Control Pavement Markings and Signing Standards – TC-8600 and 8700 Series.
Publication 13M	The Department's Design Manual Part 2: Highway Design.
Publication 148	The Department's Traffic Standards (TC-8800 Series Signals).
Publication 149	The Department's Traffic Signal Design Handbook.
Publication 212	The Department's Official Traffic Control Devices, that contains the regulation, Chapter 212 of Title 67 of the Pennsylvania Code (67 Pa. Code Chap. 212). The Chapter 212 regulation adopts and supplements FHWA's Manual on Uniform Traffic Control Devices (MUTCD).
Publication 213	The Department's Temporary Traffic Control Guidelines.
Publication 236M	The Department's Handbook of Approved Signs.
Publication 287	The Department's publication showing the unit cost bid prices for construction projects during recent years.
Publication 35	The Department's listing of Approved Construction Materials, commonly referred to as Bulletin 15.
Publication 408	The Department's Highway Specifications.
Publication 441	The Department's regulation entitled "Access to and Occupancy of Highways by Driveways and Local Roads."
Publication 46	The Department's Traffic Engineering Manual.
Publication 70M	The Department's Guidelines for the Design of Local Roads and Streets.
Publication 72M	The Department's Roadway Construction Standards.
Push Button Detection	A mechanical switch that, when pushed or activated, tells the controller of the presence of a pedestrian.
Radar detection	A detector that uses radar waves to track vehicles as they approach and leave an intersection.

Term	Definition
Red Clearance Interval	An interval which follows the yellow change interval during which no green indication is shown on any conflicting phase.
Response Maintenance	Emergency repair performed on an as-needed basis due to either equipment failure or a crash. Upon notification, the maintenance service team is dispatched to secure the site, diagnose the problem, perform the repairs, and record its activities as quickly as possible.
Rest	The state in which a controller unit rests until called out of the phase.
Semi-Traffic-Actuated Controller Operation	A type of traffic operation in which means are provided for traffic actuation on one or more, but not all, approaches to the intersection.
Signal Face	That part of a signal head provided for controlling traffic in a single direction. Turning indications may be included in a signal face.
Signal Head	An assembly containing one or more signal faces which may be designated accordingly as one-way, two-way, etc.
Signal Indication	The illumination of a traffic signal lens or equivalent device or a combination of several lenses or equivalent devices at the same time. (Note: This term usually means indications to vehicular traffic; however, pedestrians may be using these indications if no Pedestrian Signal Indications are present.)
Source of Power (SOP)	The location of the electrical service equipment associated with a traffic signal, or the location where electrical connection is made to the power company distribution system.
Split Time	A division of the cycle allocated to each of the various phases green, yellow, and all-red time.
Title 67 of the PA Code	The “Transportation Title” of the Pennsylvania Code which contains regulations of the Department, typically in response to a legislative mandate.
Traffic Control Signal	The specific type of traffic signal that provides alternating stop-and-go traffic control with red-yellow-green (R-Y-G) signal indications.
Traffic Signal	The broad category of highway lights including traffic control signals (provide alternating stop and go), pedestrian signals, flashing beacons, lane-use control signals, ramp metering, and in-roadway lights.
Traffic Signal Housing	The outer part of a traffic signal section that protects the light and other required components from the elements.

Term	Definition
Traffic Signal Permit	The document approved by the Department to authorize the installation and operation of the traffic signal. The traffic signal permit is for a traffic signal at a specific intersection. It includes the Traffic Engineering Form TE-964, and traffic signal plans showing the intersection plan sheets with the locations of the traffic signals, traffic signal supports, controller cabinet, junction boxes, detectors, stop lines, street names, approach grades, distance to nearest signals, etc., plus the traffic signal phasing diagram.
Traffic Signal Support	The physical means whereby signal heads, signs, and luminaires are supported in a particular location. Structural supports are to be designed to carry the loads induced by attached signal heads, signs, luminaires, and related appurtenances.
Traffic Signal System	Two or more traffic control signals operating in coordination with each other.
Traffic Signal Timing	The analysis of intersection geometrics, speeds, and historical traffic volumes used to identify the specific duration in seconds for the green, yellow, red, Walk, and Don't Walk intervals of each phase. For traffic actuated signals, the traffic signal timing also includes information on the incremental extensions of the green intervals due to the continued presence of approaching vehicles.
Uninterrupted Power Supply (UPS)	A battery backup system designed to instantly provide electrical power for the operation of the controller and traffic signals during a power outage.
Video Detection	The process of using a video imaging system to analyze the feed from a video camera mounted above the roadway to determine the presence or passage of vehicles in one or more specific travel lanes on an approach to the intersection.
Walk Interval	The portion of a traffic phase that permits pedestrians to leave the curb.
Wireless Detection	The use of equipment coupled with a radio transmitter that informs a receiver in the controller cabinet of the presence or passage of vehicles in one or more specific travel lanes. The type of detection may vary, but the radio transmission is used in lieu of wire or coaxial cable.
Yellow Change Interval	The first interval following the green right-of-way interval in which the signal indication for that phase is yellow, indicating that the right-of-way for that phase is about to terminate.

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CHAPTER 2. APPLICABLE PUBLICATIONS AND FORMS

All of the publications and forms identified in this section are available online from the PennDOT traffic signal portal (see Section 1.5). The website for the portal is:

www.dot.state.pa.us/Portal%20Information/Traffic%20Signal%20Portal/Index.html

Be sure to check the website for updates to these documents.

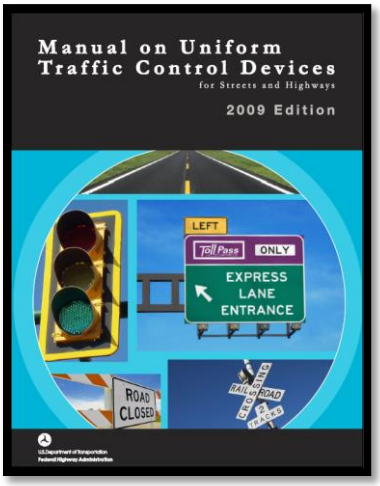
2.1 Manual on Uniform Traffic Control Devices (MUTCD)

The Federal Highway Administration (FHWA) publishes the MUTCD, which contains all national design, application, and placement standards, guidance, options, and support provisions for traffic control devices. At the time of publication of this manual, the 2009 edition dated December of 2009 is the current version with revisions 1 and 2 which became effective June 13, 2012. The national MUTCD website is located at:

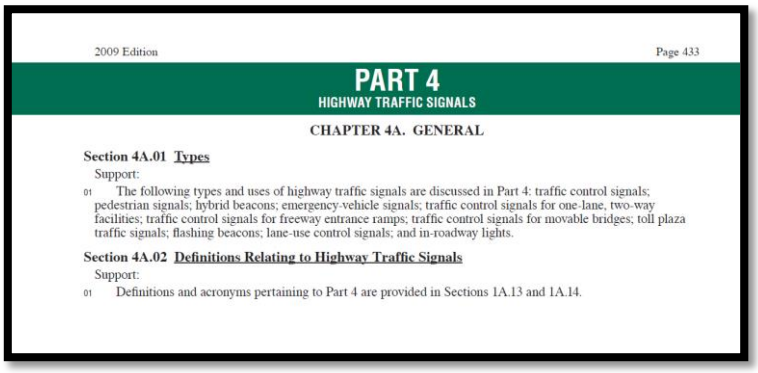
http://mutcd.fhwa.dot.gov/index.htm.

The purpose of the MUTCD is to provide uniformity of these devices, which include signs, signals, and pavement markings, and to promote highway safety and efficiency on the nation's streets and highways. Exhibit 2-1 shows the cover of the 2009 national MUTCD. Part 4, Chapter 4A to 4N of the MUTCD is dedicated to highway traffic signals.

Exhibit 2-1 2009 National MUTCD



Part 4 of the MUTCD related to Traffic Signals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PART 4
HIGHWAY TRAFFIC SIGNALS

CHAPTER 4A. GENERAL

Section 4A.01 Types

Support:

01 The following types and uses of highway traffic signals are discussed in Part 4: traffic control signals; pedestrian signals; hybrid beacons; emergency-vehicle signals; traffic control signals for one-lane, two-way facilities; traffic control signals for freeway entrance ramps; traffic control signals for movable bridges; toll plaza traffic signals; flashing beacons; lane-use control signals; and in-roadway lights.

Section 4A.02 Definitions Relating to Highway Traffic Signals

Support:

01 Definitions and acronyms pertaining to Part 4 are provided in Sections 1A.13 and 1A.14.

Title 23 of the Code of Federal Regulations (CFR) requires all states to do one of three things within two years after a new national MUTCD edition is issued or any national MUTCD amendments are made:

- ✓ adopt the new or revised national MUTCD as the standard for traffic control devices in the state;

- ✓ adopt the national MUTCD with a state supplement that is in substantial conformance with the new or revised national MUTCD; or
- ✓ adopt a state MUTCD that is in substantial conformance with the new or revised national MUTCD.

In the 67 Pa. Code § 212.2, the Commonwealth of Pennsylvania has adopted the national MUTCD unless otherwise specified in the regulation, as published by the Federal Highway Administration (FHWA). The direct language is:

§ 212.2. Adoption of Federal standards.

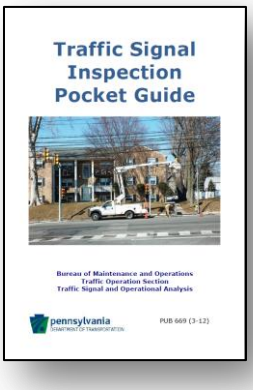
(a) General provisions. Consistent with the authority contained in 75 Pa.C.S. § § 6103(c) and 6121 (relating to promulgation of rules and regulations by the Department; and uniform system of traffic-control devices), the Department hereby adopts the MUTCD, as published by the Federal Highway Administration. The MUTCD is adopted in its totality except where this chapter clearly indicates that it is not being adopted, or that additional warrants or criteria are being provided.

(b) Modification of Federal statutes, regulations or provisions. As provided in 75 Pa.C.S. § 6103(d), if the MUTCD is amended or modified by the Federal Highway Administration, the amendment will take effect on the effective date specified by the Federal Highway Administration unless the Department publishes a notice in the Pennsylvania Bulletin stating that the amendment or modification will not apply.

Note: As of November 19, 2011, PennDOT has adopted the 2009 national MUTCD.

2.2 Publication 669 – Traffic Signal Inspection Pocket Guide

Publication 669 is intended to assist the inspector (either on construction projects or Highway Occupancy Permit projects) in recognizing the components of a traffic signal, ensuring that all contract requirements are met in the traffic signal installation, and as a roadmap to the PennDOT traffic signal requirements. Although most common situations are addressed by standards, specifications and this handbook, not all situations may be covered and may require additional assistance from the District Signal Supervisor. Additionally, if field conditions differ from those shown on the plan or something doesn't seem to make sense, contact the Inspector In-Charge and the District Signal Supervisor as soon as possible to determine the proper course of action.

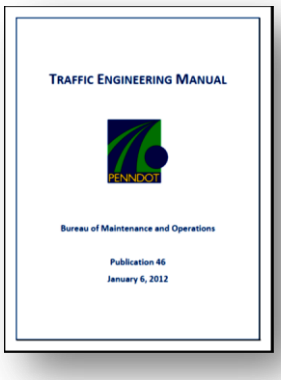


Chapter 6 and additional portions of this training manual are based on Publication 669 with additional details and information included.

2.3 Publication 35 – Bulletin 15 Approved Material

Bulletin 15 is a listing of prequalified materials that are eligible for use on Department construction projects. The purpose of Bulletin 15 is to provide contractors, consultants, Department personnel, manufacturers, suppliers, and others with easy access to a complete and accurate listing of approved products and their approved uses. Additional details on Publication 35 are described in Section **4.2 - Traffic Signal Product Approvals**.

2.4 Publication 46 – Traffic Engineering Manual



Publication 46 is the Department's Traffic Engineering Manual. The chapters included in Publication 46 are:

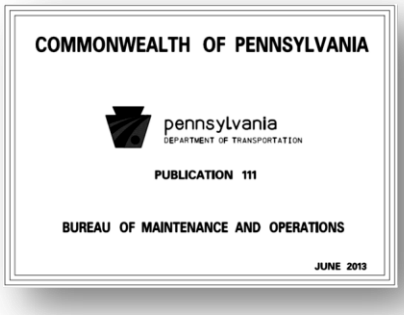
1. General
2. Signing
3. Markings
4. **Traffic Signals**
5. Low-Volume Roads
6. Temporary Traffic Control
7. School Areas
8. Highway-Rail Grade Crossings
9. Bicycle Facilities
10. Highway Capacity Manual and Data Collection Parameters - reserved
11. Traffic Studies
12. Traffic Engineering Software
13. Intelligent Transportation Systems (ITS) – reserved

As noted, Chapter 4 is focused on traffic signals.

2.5 Publication 72M – Standards for Roadway Construction

Publication 72M is the Department's Roadway Construction Standards. The standard drawings detail earthwork, pavements, drainage, guide rail and median barriers, fences and curbs, erosion and sedimentation control, highway lighting, and roadside development and planting. Of particular interest is Standard Drawing RC-67M. These standard drawings define the details required for curb ramps and sidewalk features in order to satisfy the ADA requirements.

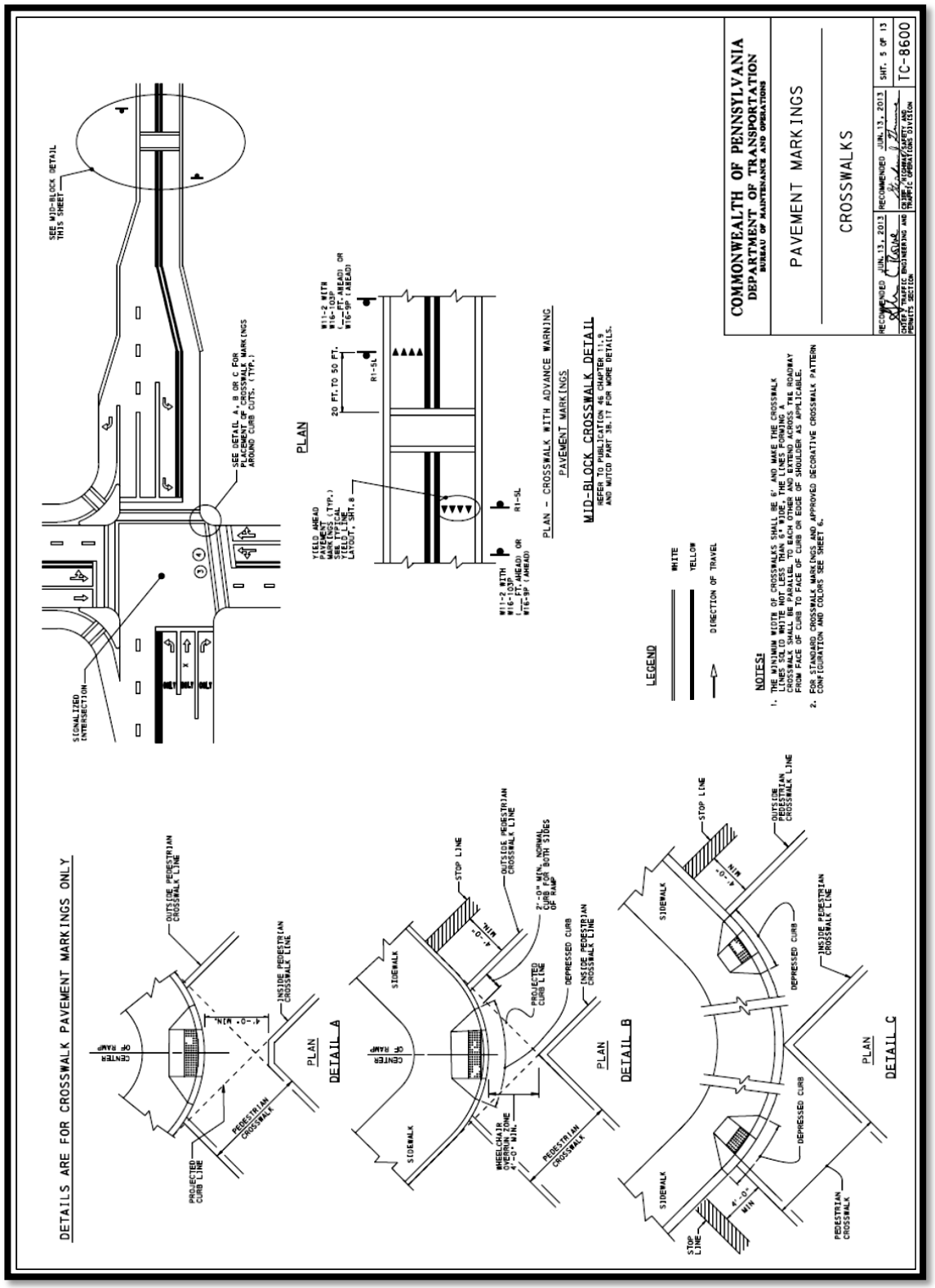
2.6 Publication 111 – Traffic Control Pavement Markings and Signing Standards (TC-8600 and TC-8700 Series)



Publication 111 is the Department's standard drawings to be used for the design, details and installation for traffic control Signs and Pavement Markings. The following are the Standard Drawings in the publication:

Standard Drawing No.	Description
TC-8600	Pavement Markings
TC-8602	Snowplowable Raised Pavement Markings
TC-8604	Delineation
TC-8700C	Spacing Charts / Direct Applied Letters, Numerals & Arrows
TC-8701A	Advance Signing For Interchanges
TC-8701D	Details / Freeway & Expressway Guide Signs
TC-8701E	Extruded Aluminum Channel Signs
TC-8701P	Freeway & Expressway Advance Signing For Parking Areas
TC-8701R	Freeway & Expressway Advance Signing For Rest Areas
TC-8701S	Flat Sheet Aluminum Signs With Extruded Aluminum Stiffeners
TC-8701W	Freeway & Expressway Advance Signing For Welcome Centers
TC-8702A	Post-Mounted Signs, Type A
TC-8702B	Post-Mounted Signs, Type B
TC-8702C	Post-Mounted Signs, Type C
TC-8702D	Post-Mounted Signs, Type D
TC-8702E	Post-Mounted Signs, Type E
TC-8710	Distance Markers
TC-8715	Sign Lighting
TC-8716	Type III Barricade
TC-8717	Temporary Portable Sign Post, "H" Base And "X" Base

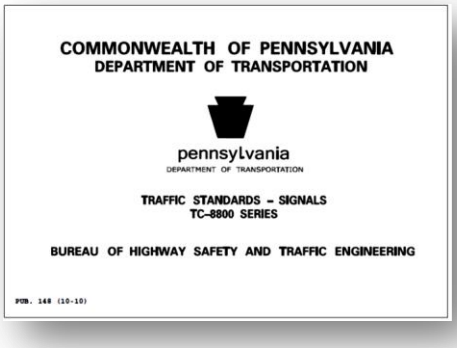
Exhibit 2-2 TC-8600 Sheet 5 of 13 Example from Pub 111



2.7 Publication 148 – Traffic Standards (Signals, TC-8800 Series)

Publication 148 is the Department's traffic signal standards. This includes standard drawings for a variety of traffic signal components. The following is a summary of the standard drawings included in the Publication:

Standard Drawing No.	Description
TC-8801	Traffic Signal Support
TC-8802	Controller Assembly
TC-8803	Miscellaneous
TC-8804	Electrical Distribution
TC-8805	Signal Heads
TC-8806	Detectors

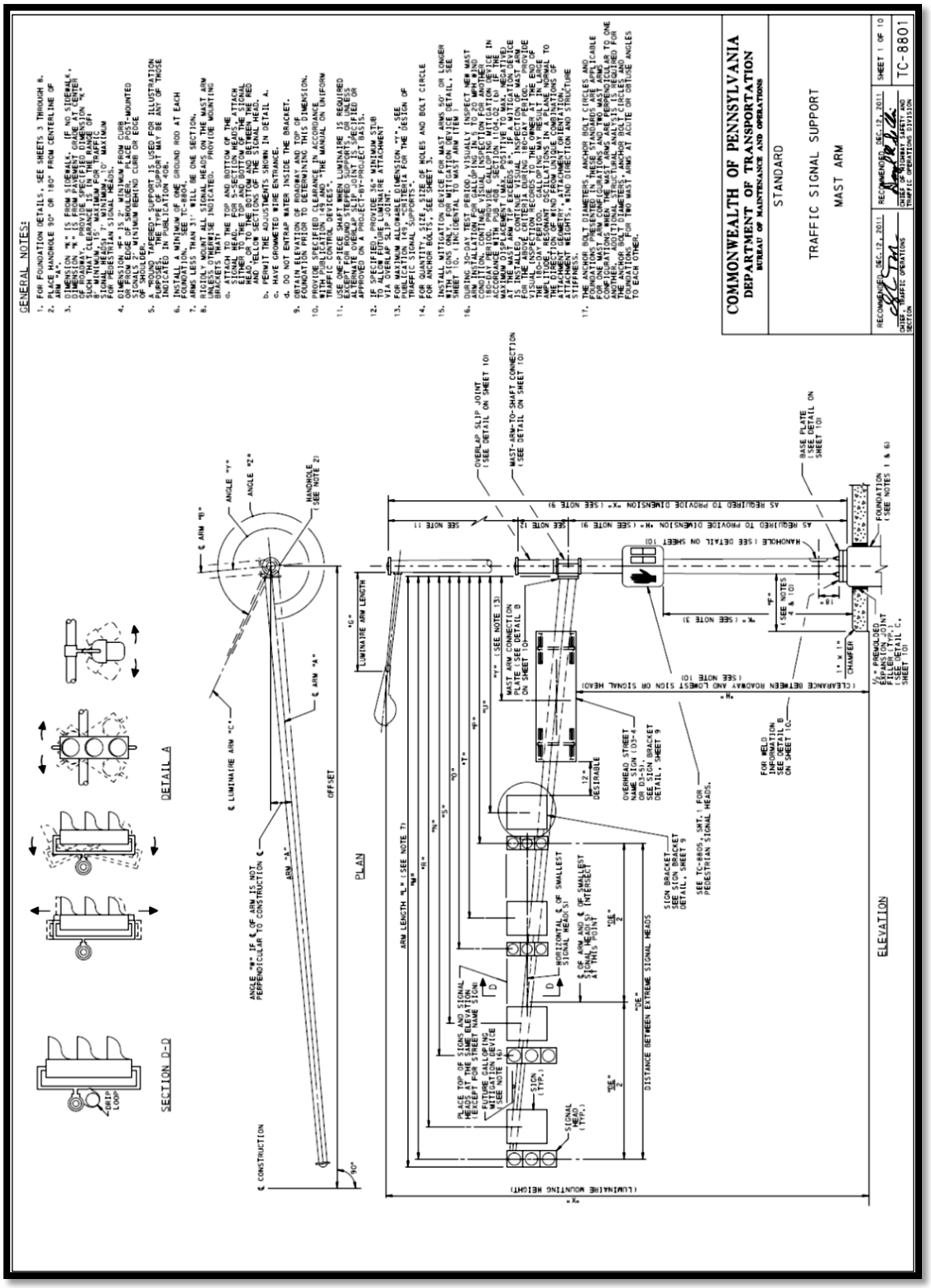

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
pennsylvania
DEPARTMENT OF TRANSPORTATION
TRAFFIC STANDARDS – SIGNALS
TC-8800 SERIES
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

The standards can be obtained from the following FTP site:

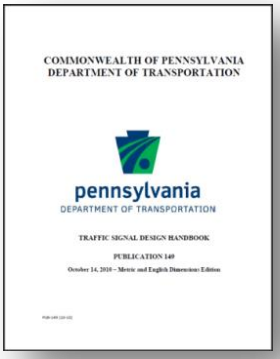
ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20148.pdf

The exhibit on the following page is an example of TC-8801, page 1 of 10 as a standard drawing for the traffic signal support system (mast arm).

Exhibit 2-3 TC-8801 Sheet 1 of 10 Example from Pub 148

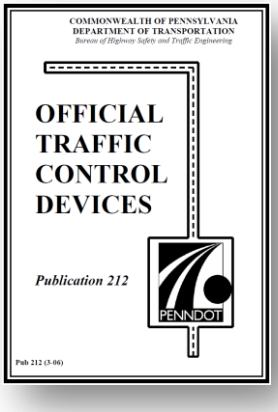


2.8 Publication 149 – Traffic Signal Design Handbook



Publication 149 is the Department's Traffic Signal Design Handbook. The purpose of this publication is to provide design guidance when developing a new, or modifying an existing, traffic signal in Pennsylvania. This publication provides the necessary guidance in preparing appropriate construction and traffic signal permit plans. This manual assumes that a traffic signal has already been approved based on the traffic signal warrants defined in Publication 46 (Traffic Engineering Manual) and the national Manual on Uniform Traffic Control Devices (MUTCD).

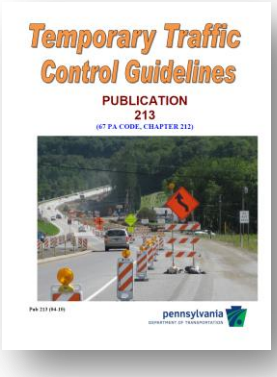
2.9 Publication 212 – Official Traffic Control Devices



Publication 212 is the Department's Official Traffic Control Devices and contains the regulation, Chapter 212 of Title 67 of the Pennsylvania Code (67 Pa. Code Chap. 212). The Chapter 212 regulation adopts and supplements FHWA's Manual on Uniform Traffic Control Devices (MUTCD).

With the promulgation of Chapter 212, the most recent edition of the MUTCD becomes the standard for traffic control in the Commonwealth as provided in 75 Pa.C.S. §§ 6103(c) and 6121 (relating to promulgation of rules and regulations by department; and uniform system of traffic-control devices).

2.10 Publication 213 – Temporary Traffic Control Guidelines



Publication 213 is the Department's Temporary Traffic Control Guidelines. Publication 213 applies to contractors; utilities; federal, state, county, township and municipal governments; and others performing applicable construction, maintenance, emergency or utility/permit work on highways or so closely adjacent to a highway that workers, equipment or materials encroach on the highway or interfere with the normal movement of traffic.

The traffic control schemes shown in the publication are for urban and rural conditions. Since it is not practical to provide detailed guidelines for all the situations that may conceivably arise, applications are presented for only the most common situations. These are minimum desirable applications for normal situations, and additional protection may be needed when special complexities or potential hazards prevail.

2.11 Publication 408 – Standard Specifications

Publication 408 provides the Department's highway construction specifications and details specifications for most highway construction projects. The publication is divided into the following sections:

- ✓ Section 100 – General Provisions
- ✓ Section 200 – Earthwork
- ✓ Section 300 – Base Courses
- ✓ Section 400 – Flexible Pavements
- ✓ Section 500 – Rigid Pavements
- ✓ Section 600 – Incidental Construction
- ✓ Section 700 – Material
- ✓ Section 800 – Roadside Development
- ✓ Section 900 – Traffic Accommodation and Control
- ✓ Section 1000 – Structures
- ✓ Section 1100 – Manufactured Material
- ✓ Section 1200 – Intelligent Transportation Systems (ITS) Devices

Of particular interest for traffic signals, Section 900 is related to traffic control, Section 1000 on structures and Section 1100 on Manufactured Materials. The sections are generally divided into four (4) subsections that include:

- ✓ Description
- ✓ Material
- ✓ Construction
- ✓ Measurement and Payment

A handout of Section 1104 is included at the end of the chapter in Section **2.15**.

2.11.1 Navigating through Publication 408

Publication 408 – Highway Specifications is an important document for those involved with a construction project. This includes, but is not limited to, the project manager, designer, contractor, inspector, etc. Publication 408 contains numerous details on construction materials, and understanding how to navigate the publication is important. The publication is available in a hardcopy format or online at:

www.dot.state.pa.us/Internet/Bureaus/pdDesign.nsf/ConstructionSpecs408and7?readForm

In either format, you can start from the Table of Contents as illustrated in **Exhibit 2-4**. In the online version, you can click on the blue underlined "Section" to jump to that section. In the hard-copy version, use the section or page to turn to that section/page.

Exhibit 2-4 Publication 408 Navigation via the Table of Contents

SECTION 900 — TRAFFIC ACCOMMODATION AND CONTROL

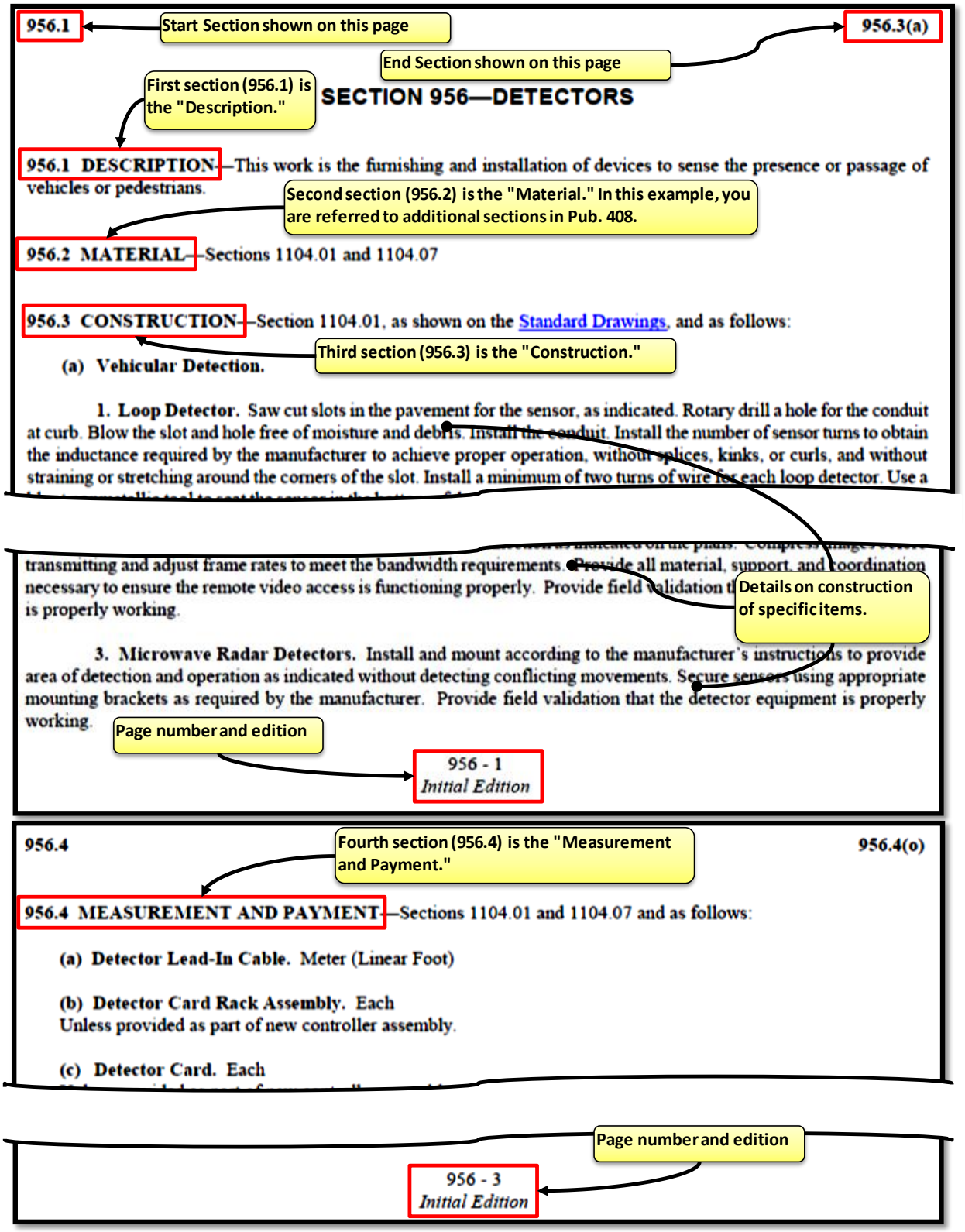
Section		Page From	Page To
901	MAINTENANCE AND PROTECTION OF TRAFFIC DURING CONSTRUCTION	901 – 1	901 – 10
902	MAINTENANCE AND PROTECTION DURING TEMPORARY SUSPENSION OF WORK	902 – 1	902 – 1
903	TEMPORARY BRIDGE AND APPROACHES	903 – 1	903 – 1
910	HIGHWAY LIGHTING	910 – 1	910 – 8
948	STEEL SIGN STRUCTURE	948 – 1	948 – 4
951	TRAFFIC SIGNAL SUPPORTS	951 – 1	951 – 1
952	CONTROLLER ASSEMBLY	952 – 1	952 – 2
953	TRAFFIC SIGNAL SYSTEMS AND COMMUNICATIONS	953 – 1	953 – 5
954	ELECTRICAL DISTRIBUTION	954 – 1	954 – 5
955	SIGNAL HEADS	955 – 1	955 – 1
956	DETECTORS	956 – 1	956 – 3
960	HOT THERMOPLASTIC PAVEMENT MARKINGS	960 – 1	960 – 2
961	COLD ...IGS OR LEGENDS	961 – 1	961 – 1
962	WATE...IGS	962 – 1	962 – 3
963	PAVE...	963 – 1	963 – 1
964	EPOX...	964 – 1	964 – 3
965	PREFORMED THERMOPLASTIC PAVE...	965 – 1	965 – 2
966	SNOWPLOWABLE RAISED PAVEMEN...	966 – 1	966 – 2
970	REMOVE POST MOUNTED SIGNS, TYPE A	970 – 1	970 – 1
971	REMOVE POST MOUNTED SIGNS, TYPE B	971 – 1	971 – 1
972	REMOVE POST MOUNTED SIGNS, TYPE C	972 – 1	972 – 1
974	REMOVE POST MOUNTED SIGNS, TYPE E	974 – 1	974 – 1
975	REMOVE POST MOUNTED SIGNS, TYPE F	975 – 1	975 – 1

From the online Pub. 408 Table of Contents, click the desired section here

From the printed Pub. 408, navigate to the desired page(s) listed here

The section 900 series are related to Traffic Accommodation and Control and are divided into subsections for description, material, construction, and measurement and payment. **Exhibit 2-5** contains sample pages from Section 956 on Detectors. This illustrates the items found within the sample section. The other sections are similarly laid out.

Exhibit 2-5 Sample Pages from Publication 408 (956 – Detectors)



2.12 Form CS-201, Source of Supply – Traffic Items

Materials/Suppliers Approval - Standard forms for Materials Source of Supply (Form CS-200 Source of Supply–Materials and Form CS-201 Source of Supply–Traffic Items) are shown in **Exhibit 2-6** and **Exhibit 2-7**. A cover letter/memo and these forms must be submitted to the District at least two (2) days in advance of the pre-construction meeting. In order for the forms to be used as intended, the following requirements need to be met where applicable:

- ✓ The prime contractor MUST submit a cover letter or memo with the completed respective forms to the District for each project. This may be done by mail or electronically to expedite the process, but should be submitted by an individual responsible for and able to respond to any Department questions relating to the sources of supply.
- ✓ Use contract item numbers and descriptions of the materials being provided as noted in the contract.
- ✓ Provide I.D. codes or model numbers as listed in the appropriate Bulletin.
- ✓ Include the specific section number as listed in the specific Bulletin.
- ✓ All traffic items must have the Department's Certificate of Approval Number or specification number included.
- ✓ Generally, submit the primary source of supply of each item in the letter/memo to the District. While not required, two sources may be provided for specific items if a back-up source is envisioned as necessary. The primary and backup source should be identified as such. However, written notification is required if the backup source is going to be used.
- ✓ If there are changes made to the source of supply, the most current source of supply letter/memo will supersede previous submittals.
- ✓ Only resubmit items that were not previously approved on previous letters. It is not necessary to resubmit the entire list of materials.
- ✓ For concrete and asphalt items include the following:
    - An item number as listed in contract.
    - The producer's/manufacturer's name and location as listed in Bulletin 14 (Aggregate Producers), Bulletin 15 (Approved Construction Materials), Bulletin 41 (Producers of Bituminous Mixtures) or Bulletin 42 (Producers of Redi-Mixed Concrete).
    - Name/Description of material to be used.
    - The Mix Design Code number.
    - Discuss the requirements of Material Certifications (Form CS-4171) and the contractor's quality control plan.

Exhibit 2-6 Form CS-200, Source of Supply – Materials

Page 1 of 5

CS-200 (6-05) Fillable Fields/Save As

Source of Supply-Materials

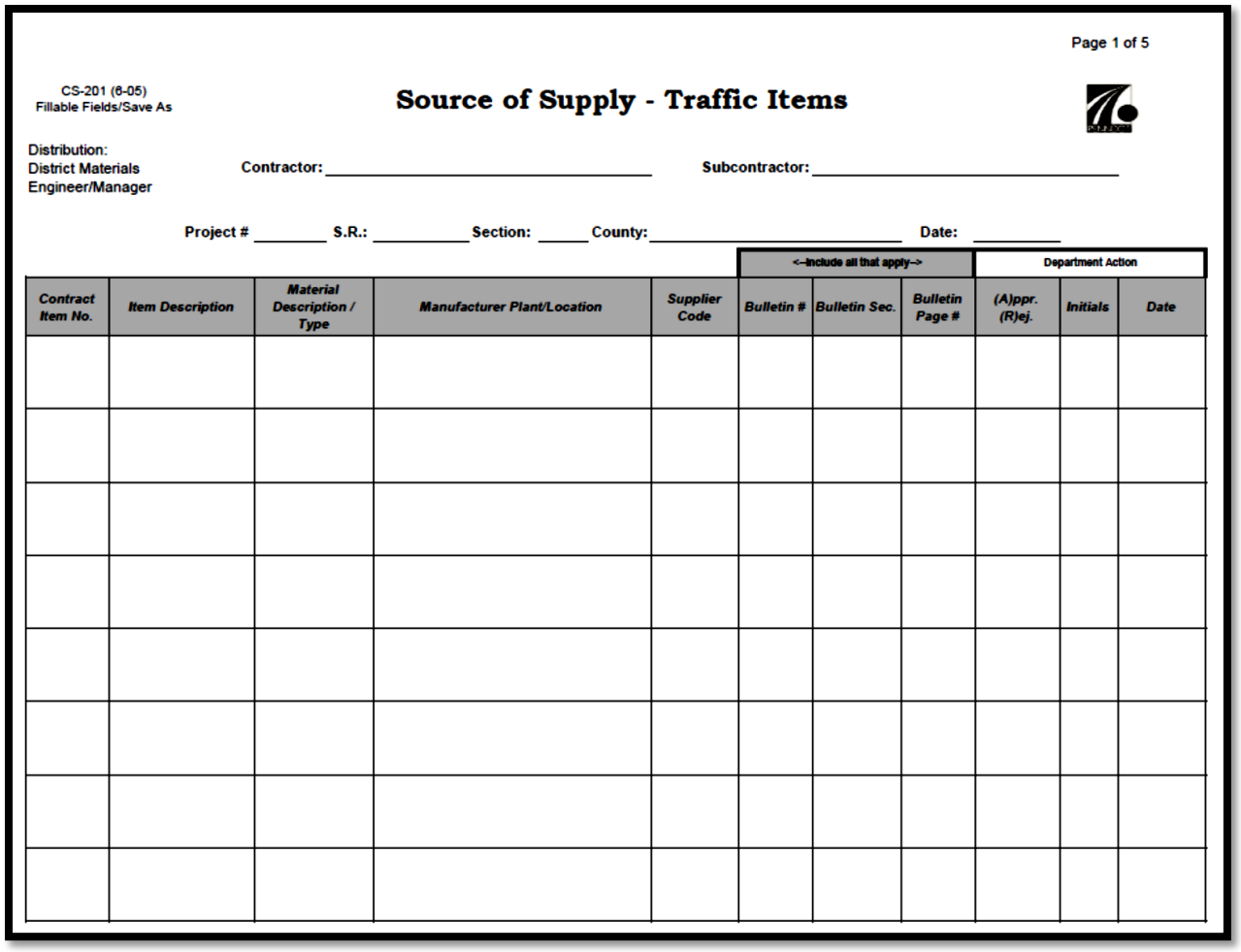
Distribution:
District Materials
Engineer/Manager

Contractor: _____ Subcontractor: _____

Project # _____ S.R.: _____ Section: _____ County: _____ Date: _____

Contract Item No.	Item Description	Material Description / Type	Manufacturer Plant/Location	Supplier Code	Bulletin #	Bulletin Sec.	Bulletin Page #	Department Action (A)ppr (R)ej.	Department Action Initials	Department Action Date

Exhibit 2-7 Form CS-201, Source of Supply – Traffic Items



Page 1 of 5

CS-201 (6-05)
Fillable Fields/Save As

Source of Supply - Traffic Items

Distribution:
District Materials
Engineer/Manager

Contractor: _____ Subcontractor: _____

Project # _____ S.R.: _____ Section: _____ County: _____ Date: _____

					<--Include all that apply-->			Department Action		
Contract Item No.	Item Description	Material Description / Type	Manufacturer Plant/Location	Supplier Code	Bulletin #	Bulletin Sec.	Bulletin Page #	(A)ppr. (R)ej.	Initials	Date

2.13 Form 4170, Product Evaluation Application

The Product Evaluation Application, Form CS-4170, is the means to submit products for consideration for approval and listing in Bulletin 15 (See Exhibit 2-8). Additional information on the product approval process is detailed in Section 4.2.

2.14 Form 4171, Certificate of Compliance

Per Publication 35 – Bulletin 15 (see Section 2.3 and Section 4.2), a completed Form 4171, "Certificate of Compliance" must be submitted, with each shipment of material to the project.

Exhibit 2-9 is a sample of this form. In addition, the Department has two supplemental forms (not shown in this document): Form CS-4171C "Supplemental Certification for Epoxy Coated Reinforcement – Coating Facility" and Form CS-4171F "Supplemental Certification for Epoxy Coated Reinforcement – Fabrication Facility," which are to be used specifically by coaters and fabricators of epoxy coated reinforcement steel.

Exhibit 2-8 Form 4170, Product Evaluation Application

CS-4170 (10-12) (This box for PennDOT use only)

PE ☐ PEQ ☐

pennsylvania DEPARTMENT OF TRANSPORTATION

Bureau of Project Delivery
Product Evaluation Application

Evaluation Number: _____

Date Received: _____

Date Processed: _____

Please review these Instructions before completing the application! (Click to View)

SECTION 1
COMPANY / MANUFACTURER INFORMATION

Identify the type of operation most applicable to your Facility/Business (choose only one):

Manufacturer	Steel (Epoxy Coater or Galvanizer) - or - Wood Treater	Steel, Aluminum or Timber Fabricator	Machine Shop or Paint Shop	Precaster or Prestressed Concrete Producer	Cement Plant/Terminal or Pozzolan Provider	Bituminous Refinery or Terminal
☐	☐	☐	☐	☐	☐	☐

Company / Business Name:

Company / Business HQ Address:

City: State: Zip Code:

Manufacturing Facility Name/Address ☐ (same as above); or ☐ (if different, then complete Name/Address information below):

Manuf. Facility Name (if different):

Manuf. Facility Address (if different):

City: State: Zip Code:

Company E-Mail Address (fixed):
(Ex: info@yourcompany.com)

Product Technical Expert: Phone #: Ext.

E-Mail Address:

Manuf. Facility QC Contact: Phone #: Ext.

E-Mail Address:

Licensing Company Name (if applicable):

Licensing Co. Contact: Phone #: Ext.

E-Mail Address:

CS-4170 - Page 1 of 4

Exhibit 2-9 Form 4171, Certificate of Compliance

CS-4171 (11-11)

pennsylvania DEPARTMENT OF TRANSPORTATION

CERTIFICATE OF COMPLIANCE

1. ◆COUNTY:_____ ◆LR/SR:_____ ◆SEC/SEG:_____ ◆ECMS#:_____
(◆ - To be completed by the party that will ship the material to the project, otherwise leave blank.)

2. I / WE hereby certify that the material listed on line 5 was:

☐ Manufactured ☐ Fabricated ☐ Coated ☐ Precasted ☐ Produced

By_____ _____
(Name of Manufacturer, Fabricator, Coater, Precaster or Producer) (Supplier Code)

3. and the party listed above certifies that the material(s) on line 5 meets the requirements of

Publication 408, Section(s) _____

AASHTO, ASTM, Federal or other designation _____

4. The material listed below is being shipped to:_____
(Company Name)

5. **LOT NO.** **QUANTITY** **APPROVED MATERIAL AS LISTED IN BULLETIN # 14 or 15 BULLETIN # 41 or 42 PRODUCERS, LIST HMA / PCC JMF.**

_____
_____
_____
_____
_____
_____
_____

6. ☐ **CHECK HERE IF YOUR PRODUCT CONTAINS IRON OR STEEL (AND check one of the following boxes, as appropriate.)** I / WE certify the material identified above conforms with Section 106.01 of Publication 408 as indicated below.

☐ 'Identifiable Steel' or Fabricated Structural Steel (Section 1105). Either Steel products that contain permanent markings that identify that the material was melted and manufactured in the United States or which have received in-plant inspection by the Department or a Department representative where verification of Mill Test reports was performed to verify conformance with the PA Steel Procurement Act. **Only Form CS-4171 is required.**

☐ 'Unidentified Steel' – Attach supporting documentation including invoices, bills of lading and mill test reports that positively identify that the steel was melted and manufactured in the United States.

All **manufacturing processes** including coatings application (e.g. epoxy, galvanizing, or painting) have occurred in the United States and we are maintaining copy(s), in our files in accordance with Section106.03(b)3. Note: While coating materials themselves are not covered by Buy America, the application of these materials on steel or iron must occur in the United States.

7. **VENDOR CLASSIFICATION (CHECK ONE BLOCK ONLY) -**

☐ **#1 Manufacturer, Fabricator, Coater, Precaster Listed in Bulletin # 15, or Producer Listed in Bulletin # 14, 41 or 42**
I certify that the above statements are true and to the best of my knowledge, fairly and accurately describe the product(s) listed.

☐ **#2 Distributor, Supplier or *Private Label Company Not Listed in Bulletin # 15. Also, complete line 9**
I certify that the material being supplied is one and the same as provided to us by the manufacturer listed on this document and quantities listed above are accurate.

8. **NAME (print) :** _____ **TITLE:**_____

COMPANY NAME : _____

SIGNATURE : _____ **DATE:** _____
By Responsible Company Official **(QC Staff only if you checked block #1 on line 7)**

9. List company that sold you the material(s) documented above: _____
(Complete if you checked Block # 2 on line # 7, otherwise leave blank.) (Company Name)

2.15 Publication 408 Section 1104 Handout

The information on the following pages is a handout from Publication 408, Section 1104, including the following subsections:

- ✓ 1104.01 - General Requirements
- ✓ 1104.02 - Traffic Signal Supports
- ✓ 1104.03 - Controller Assembly
- ✓ 1104.04 - Systems and Communications
- ✓ 1104.05 - Electrical Distribution
- ✓ 1104.06 - Signal Heads
- ✓ 1104.07 - Detectors

It is recommended that you review all original reference material to check for updates. The publication is available in a hardcopy format or online at:

www.dot.state.pa.us/Internet/Bureaus/pdDesign.nsf/ConstructionSpecs408and7?readForm

SECTION 1104—TRAFFIC SIGNALS

1104.01 GENERAL REQUIREMENTS—Comply with the requirements of associations, societies, codes, and regulations, as applicable, pertaining to the work of furnishing and installing operational traffic signals; including traffic signal supports, controller assemblies, traffic signal systems and communications, electrical distribution, traffic signal indications, and detectors.

Words and phrases specific to traffic signals that are not defined in these specifications or in the regulations, are to be defined as in NEMA TS 1, NEMA TS 2, Type 170-ATC, or Type 2070-ATC industry standards.

(a) Traffic Signals Materials Acceptance. Before the submission of a bid proposal, verify that Bulletin 15 approved products issued by the Department, for traffic signal equipment, as provided in 67 PA Code, Chapter 212.

At least 3 weeks before their installation, submit to the Representative, for review and acceptance, a tabulation of all project traffic signal materials. Include the type of material, manufacturer's name, model number, and the Department's Certificate of Approval number for each item to be supplied. Refer to Publication 46 to obtain the listing of traffic signal items that require Bulletin 15 approval. Provide catalog cuts for further clarification of the material, when requested.

(b) Structural Material. Fabricate traffic signal structural material according to Section 1105 (steel members only), AWS, and the AASHTO Specifications; except, applying water to the base metal during plasma arc cutting is permitted. Bulletin 15 listing and shop inspection is required. Fabricators provide an AWS certified welding inspector (CWI) for welded steel or aluminum pole products as specified in Section 1105.01(g)3. Bulletin 15, shop inspection, and Section 1105 do not apply to painting of aluminum poles and for the following non-welded items: cast aluminum poles, cast steel poles, and cast iron poles.

The Charpy V-Notch toughness test is required for load carrying tension members greater than 1/2-inch in thickness, as required for Zone 2, non-fracture critical criteria, of the applicable AASHTO specifications.

Provide steel poles that either round or multi-sided with a minimum of eight sides.

Provide testing and test methods according to AWS D1.1 (Steel) or AWS D1.2 (Aluminum) and as determined by the LTS.

Provide non-destructive testing on 100% of full penetration groove welds and a random 25% of partial penetration groove welds of longitudinal seams on steel poles and arms. When inspecting full penetration seam welds, use radiographic test methods on material less than 5/16-inch in thickness, and use radiographic or ultrasonic test methods on material 5/16-inch and greater in thickness. Use magnetic particle inspection on partial penetration seam welds.

Provide non-destructive testing by ultrasonic test methods on random 25% of all pole to base plate and arm to arm plate full penetration groove welds. For tube material less than 5/16-inch in thickness, have the fabricator submit a detailed ultrasonic testing procedure, including acceptance criteria, to the LTS for review and approval before testing.

For all other welds on steel traffic poles, perform magnetic particle inspection on a minimum of 25% of the length of each weld. Provide inspection for the full length of the weld when less than 6 inches in length.

For aluminum traffic pole structures, perform fabrication and non-destructive testing in accordance with Section 1101.01.

Where less than 100% of the weld is non-destructively tested, and a rejectable defect is found, test 100% of the length of the weld.

Where applicable, the Department’s plant inspector will select portions of welds to be tested.

Perform and evaluate all non-destructive testing according to cyclically loaded non-tubular tension criteria.

(c) Certification. As specified in Section 106.03(b)3. Certify from the manufacturer, that all signal supports satisfy the Department's criteria and are adequate to support the loads indicated on the approved plans. Include on the certification the signature and seal of a Professional Engineer registered in the State. Certify the structural adequacy of all sign and signal brackets as well as all other mounting hardware.

(d) Traffic Signal Controllers. Provide switches, controls, and indicators that are operable without the use of tools. Clearly and permanently identify the switches, controls, and indicators.

Furnish three copies of warranties, guarantees, instruction manuals, wiring diagrams, and parts’ lists with each different type material. Also, provide in the controller assembly cabinet one instruction manual for each controller unit, time clock, and coordination unit.

Upon completion of a controller assembly, conduct a physical and functional shop test of the assembly's continuous, satisfactory operation, for not less than 7 calendar days, in accordance with industry standards. Provide 300 W loads for signal circuit and simulated inputs for detectors, and interconnection. Certify that the equipment operates as indicated. Demonstrate and provide written documentation that the conflict monitor or malfunction management unit will cause transfer of the signals to flashing operation upon sensing all possible conflicting signal indications.

Label the load switch sockets and cable connectors for detector amplifiers, in the controller assembly, according to function.

All equipment which requires a separate device to set, adjust, or read the timing intervals, furnish plans or programs with one of these devices for each ten units or fraction thereof.

(e) Wiring Diagrams and Timing Plans. Provide three copies of the cabinet wiring diagram, traffic signal equipment wiring diagram, approved plans, and manufacturer's timing plan for each controller assembly, in accordance with the approved signal construction drawings. Place a clear protective envelope in the controller assembly cabinet that contains one copy of the manufacturer's instruction manual for each controller unit, time clock, coordination unit, software programming manuals, time setting charts, wiring diagrams, and parts list. Upon completion of the 30-day test, if there were any changes that would affect a change to these documents, then provide three new copies of each.

(f) Shop Testing. Submit results from shop tests to the Representative as specified in Section 952 and most recent publication for the applicable controller type as follows:

- NEMA TS1 Standard "Traffic Control Systems" (for existing traffic control equipment)
- NEMA TS2 Standard "Traffic Controller Assemblies With NTCIP Requirements"
- Type 170 Industry Standard
- Type 2070 Industry Standard

(g) Standard Construction Practices. As shown in Sections 910.3(a) and 1105, the Standard Drawings, and as follows:

Existing traffic signals are to remain in operation, as is, until the new traffic signal equipment and devices are in place and operable unless an approved plans indicates otherwise. If it becomes necessary to turn off the existing system of signalization, obtain the District Traffic Engineer's approval, municipal concurrence, and provide flaggers or other approved means to direct traffic within the intersection during periods when the traffic signals are not operating. Place temporary poles to adequately support existing traffic signals, as indicated or directed. Provide certification to the Department that such poles have sufficient strength to support the traffic signals.

Make revisions to the existing system of signalization, as indicated or directed.

Before any excavation for placement of traffic signal or sign support poles, mark proposed locations in the field. Field review pole locations with the Representative and adjust pole locations as necessary.

Remove all existing traffic signal supports, including those with traffic signals, flashing warning devices, and lane control signs and signal equipment, unless otherwise indicated.

Maintain existing controller assemblies, as a unit. Store material on the project site. Provide a listing of the equipment for the municipal owner and make arrangements to deliver equipment to the municipal storage area. Do not damage items during removal and storage.

Abandon underground conduit, conductors, and detectors not interfering with new construction. Remove foundations and junction boxes that are designated to be abandoned and are located in an "off traveled roadway" area, to 1 foot below final grade and dispose of removed materials. Fill, compact, and landscape the resulting hole, including topsoil if necessary by the particular planting.

Repair damage to galvanized finishes.

Restore areas damaged by construction.

If any vegetation is blocking the visibility of signs or traffic signals, in the opinion of the Representative, generate and submit a list of items to the Representative. Obtain approval to remove or relocate any of the items.

If not notified by the Representative, notify the Representative as soon as it is recognized that a utility facility is causing, or will cause, an obstruction to visibility.

Before the initial turn-on, verify for the Representative that all traffic signals are working properly. Make the initial turn-on to flashing mode and full operation in the presence of the Representative between the hours of 9 AM and 2 PM, Tuesday through Thursday except holidays. Under special circumstances involving safety of motoring public, the Representative may grant exceptions to this rule. Give the Representative a minimum 7 calendar day notice before the initial turn-on. For locations presently unsignalized, flash signals for a period of 3 to 7 days.

1. 30-Day Testing. After the traffic signal installation becomes operational, conduct a continuous, 24 hour operating test for not less than 30 consecutive calendar days. Correct failures during the test period by repairing or replacing malfunctioning parts or equipment or faulty work regardless of the cause in less than 24 hours as directed. After correcting failures caused by defective equipment, material, or faulty work, re-conduct the 30-day test.

During the 30-day test period, change, adjust, or reinstall controller and/or master controller settings as directed at any time. Adjust or revise initial signal timing parameters, as directed, to optimize signal operation due to actual traffic flows and field conditions. During this time period, power and communication costs associated with maintaining the operation of the traffic signal will be the responsibility of municipality or other party that currently (or will ultimately) assume ownership or maintenance of the installation.

In addition to the provisions of Sections 105.10 and 107.10, those Department, Federal, and municipal personnel and agencies, as well as public and private interests, that are involved with the signal installation, have jurisdictional control over the installation or adjacent facilities, or will ultimately assume ownership or maintenance of the installation, will at the discretion of the Department, be allowed to observe signal turn-on, installation of initial timing parameters and any subsequent adjustment, and inspection before completion of 30-day test.

2. Equipment Guarantee. Guarantee the in service operation of mechanical and electrical equipment, related components, and the controller assembly for a period of 180 days from the date of completion of the specified 30 day field test. During this period:

- Maintain equipment in the controller cabinet. Use additional locks, as necessary, to prevent entry by others.
- Repair faulty work, repair or replace defective materials or equipment and correct malfunctions in the controller cabinet within 48 hours after starting repairs.
- Start repairs no later than the working day following notification of failures or malfunctions.
- Guarantee repairs or replacements for the balance of the 180-day guarantee period, or 30 days, whichever is the longer period.
- Repair or replacement work not performed within the guarantee period, or any extension period, will be considered latent defects as specified in Section 107.16(b).

Provide the Representative with the name and telephone number of the person to be notified in the event of failures or malfunctions during the guarantee period.

Issuance of an acceptance certificate or final settlement of the Contract does not in any respect relieve the Contractor of responsibility for the in-service guarantee period described in these Specifications.

(h) Warranties, Instruction Manuals, and Guarantees. Furnish, as specified in Sections 952, 953, 955, and 956.

1104.02 TRAFFIC SIGNAL SUPPORTS—

(a) General.

1. Design and Acceptance. Design in accordance with Publication 149. Submit shop drawings in accordance with Publication 149, including calculations for all special structures, for review and acceptance.

2. Supports. Fabricate shafts and arms in any of the following shapes and styles:

Round Tapered.

- One longitudinal seam, continuously welded, and ground or rolled flush.
- Transverse butt welds are not acceptable.
- Uniform wall thickness.
- Uniform taper, 0.14 inch maximum and 0.07 inch minimum per foot of length.

Round Stepped.

- Round pipe sections, each with not more than one longitudinal seam continuously welded and ground or rolled flush. Join sections by a hot-swaged shrink fit continuously seal-welded to prevent entrance of water.
- Uniform wall thickness for each section.
- Maximum change in diameter between stepped sections not to exceed 2 1/8 inches.

Multi-Sided Tapered.

- Maximum of two longitudinal seams, continuously welded, and ground or rolled to a maximum bead height of 1/8 inch.
- Transverse butt welds are not acceptable.
- Uniform wall thickness.
- Uniform taper, 0.14 inch maximum and 0.07 inch minimum per foot of length.
- Minimum of eight sides.

Round Untapered.

- Maximum of one longitudinal seam, continuously welded, and ground or rolled flush.
- Uniform wall thickness and diameter.
- Transverse butt welds are not acceptable

3. Cable Support. Weld a cable support to the inside top of the shaft.

4. Grounding. Weld a UL-Listed grounding lug, capable of accommodating a No. 6 AWG stranded copper cable, to the inside of the shaft adjacent to the handhole.

5. Handholes. Provide a handhole in the shaft of the poles, as shown on the Standard Drawings. Reinforce the area to develop the minimum guaranteed yield strength of the shaft. Furnish a cover and keeper chain.

6. Wire Inlets. Provide a wire inlet at each signal head or at each electrically operated sign location. Weatherproof each inlet with an insulated grommet.

Provide a deburred hole, 2 1/2-inch minimum diameter, in the flange plate and shaft, which serves as a wire entrance into the arm from inside the shaft.

Provide Type LB access fittings from Type II mounted controller cabinet into pole shaft and in pole shafts for pedestrian pushbuttons.

7. Anchor Bases.

- Fabricate the base clean, smooth, and of the dimensions necessary for adequate pole mounting and structural support.
- Provide holes for anchor bolts.
- Fabricate the base to telescope over the shaft and be secured in place by welding.

8. Galvanizing. Section 1105.02(s) and as follows:

Galvanize steel shafts and arms, including those manufactured of high strength and corrosion resistant steels, according to ASTM A 123 (AASHTO M 111). Galvanize accessories and hardware according to ASTM A 153 (AASHTO M 232).

(b) Overhead Supports. As shown on the Standard Drawings and as follows:

- Shaft and Arms—AASHTO M270/ASTM A709, Grade 36 or Grade 50, ASTM A36, ASTM A 53, ASTM A 572 Grade 50, ASTM A 501 and A 595.
- Luminaire Mounting Arms—Section 1101.03
- Anchor (Base) Plates, Flange (Arm and Column Connection) Plates, and Gusset Plates,—AASHTO

M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM A 572 Grade 50.

- Miscellaneous Shapes, plates and bars- AASHTO M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM, ASTM A 572 Grade 50 and ASTM A992.
- Flange Plate Assembly Bolts, Nuts and Washers— ASTM A325, ASTM 563 and ASTM F436. Mechanically galvanize in accordance with ASTM B695. Furnish bolts, nuts and washers for testing purposes and test as specified in Section 1050.3(c) 7.b.
- Shaft and Arm Caps—Galvanized steel (C-coat) cast iron or cast aluminum.
- Handhole CHandhole Cover Plates – AASHTO M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM, ASTM A 572 Grade 50 and ASTM A 1011
- Pipe Caps – AASHTO M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM, ASTM A 572, ASTM A 1011 or ASTM B 26
- Arm dampening – Harmonic dampening device, when provided.

(c) Pedestal Supports. As shown on the Standard Drawings and as follows:

1. Aluminum.

- Support—One length, 4 1/2-inch minimum outside diameter aluminum pipe, Schedule 40, ASTM B 210, or B 221, Alloy 6063-T6.
- Bases—Cast aluminum, ASTM B 26, or B 108, Alloy 356-T6; aluminum plate, ASTM B 209, Alloy 6061-T6.
- Pole Tops—Aluminum

2. Steel.

- Support—One length, 4 1/2-inch minimum outside diameter steel pipe, Schedule 40, ASTM A 53, Type F.
- Base—Steel casting, ASTM A 27, Grade 65-35; gray iron casting, ASTM A 126, Class 26; steel plate, AASHTO M 270 (ASTM A 709), Grade 36.

(d) Pedestrian Stub Poles. As specified in Section 1104.02(c) except having a fixed length of 60 inches and a rounded top cap to minimize injuries.

(e) Anchor Bolts. As shown on the Standard Drawings and as follows:

- Anchor Bolts—ASTM A 449 or F 1554.
- Hex Nuts—ASTM A 563M/A 563
- Washers—ASTM F 436

Galvanize the top 8 inches of bolts and all associated hardware as specified in Section 1105.02(s) (ASTM A 153), or by another acceptable method conforming to the coating thickness, adherence, and quality requirements of ASTM A 153. Furnish template prints for setting anchor bolts with each support.

(f) Wood Support Poles. When used for temporary signal installations, certify sawn material, both rough and dressed by the mill as to grade and mark in accordance with the grading rules and basic provisions of the American Lumber Standards (PS-20-70) by a lumber grading or inspection bureau or agency. If dressed, the grade mark shall be applied after dressing.

(g) Span Wire. ASTM A 475, Class A, Siemens-Martin, or ASTM B 416.

(h) Tether Wire. ASTM A 475, Class A, Siemens-Martin, or ASTM B 416.

(i) Lashing. As shown on the Standard Drawings for attaching cable to span wire.

1104.03 CONTROLLER ASSEMBLY—

(a) Type of Operation.

1. Solid-State Pretimed.

- TS 1, Section 2, Environmental Standards and Test Procedures.
- LI-1, Type FR-4, Circuit Boards.

1.a Operational Requirements.

- Cycles—Three minimum or indicated otherwise on the approved plans.
- Splits—One per cycle minimum or indicated otherwise on the approved plans.
- Settable Offsets—Three per cycle or indicated otherwise on the approved plans.
- Cycle Duration—30 seconds to 120 seconds, in 1-second increments or indicated otherwise on the approved plans.
- Signal Circuits—12 minimum, wired for 18, including terminal blocks.

1.b Interconnect.

- Offsets—1, 2, 3, or indicated otherwise on the approved plans.
- Cycle—Call Cycle 2; Call Cycle 3.
- Flashing—Remote flashing.
- Voltage—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Input—Positive true.
- Fuse—Ampacity per manufacturer's recommendations.
- Isolation—Remote common from local ground.

2. Solid-State Actuated.

- TS 1, Section 2, Environmental Standards and Test Procedures.
- TS 1, Section 13, Interface Standards.
- TS 1, Section 14, Solid-State Traffic Signal Controller Units.

3. Solid-State Actuated with Volume Density. Section 1104.03(a)1.a and with the following operational requirements:

- Variable Initial Timing—Maximum variable initial timing programmable from 0 to 60 seconds.
- Gap Reduction Timings—As indicated.
- Time Before Reduction (TBR) —As indicated.

4. Solid-State Flasher.

- Flasher—Section 1104.03(b)1.d
- Circuit Breaker—Section 1104.03(c)3
- Surge Protector—Section 1104.03(c)3
- Cabinet—Section 1104.03(b)1.f

(b) Type of Controller.

1. NEMA Controller Unit.

1.a Standards.

- TS 1, Section 2, Environmental Standards and Test Procedures
- TS 1, Section 13, Interface Standards
- TS 1, Section 14, Solid-State Traffic Signal Controller Units
- L1-1, Type FR-4, Circuit Boards (pre-timed operation)
- TS-2, Section 2, Environmental Standards and Test Procedures
- TS-2, Section 3, Controller Standards and Coordination
- TS-2, Section 5, Interface and Electrical Standards
- TS-2, Section 8, Bus Interface Unit Requirements

1.b Controller Requirements. All hardware and software must be in compliance with NEMA TS-1, TS-2 standards, and as directed by the Representative. All products must be Bulletin 15 approved products.

An approved plug-in Hand Control with cord is required in all cabinets, and a method to switch the signal controller from automatic to manual control.

Include ability to accept a contact closure (or open controller output) to reset clock on controller at a predetermined hour each day (typically 2:00 AM).

Provide Fiber Modem (as specified per the system) for the communication between local controller and master controller. Clean and connect fiber-optic cable to the new controller using procedures described in current Department and industry guidelines – Fiber Optic Association Inc. (FOA).

1.c Conflict Monitor.

- TS 1, Section 6, Conflict Monitor.
- TS 2, Section 2.3, Malfunction Management Unit Test.
- TS 2, Section 4, Malfunction Management Unit.

A minimum of one input channel for each load switch socket as specified in Section 1104.03(b)1e.

1.d Flasher Unit.

- TS 1, Section 8, Solid State Flasher.
- TS 2, Section 2.6, Flasher Tests.
- TS 2, Section 6.3, Solid-State Flasher.

1.e Load Switches.

- TS 1, Section 5, Solid-State Load Switches.
- TS 2, Section 2.5, Load Switch Tests.
- TS 2, Section 6.2, Three-Circuit Solid State Load Switch
- Operational Features: Provide Light Emitting Diode (LED) indicators to display operation. Isolate signal load from load switch input using optic couplers. Furnish a minimum of one load switch for each of the following active controller unit functions:
  - Vehicle Phase.
  - Overlapping Vehicle Phase.
  - Pedestrian Phase.

1.f Cabinet. Furnish a weatherproof controller cabinet, large enough to suitably house the traffic signal controller unit and auxiliary equipment, and conforming to the following requirements:

1.f.1 Enclosure.

- Material—Sheet or cast aluminum.
- Wall Thickness—1/8 inch minimum, reinforced where required.
- Minimum Size—As shown on the Standard Drawings and as follows:

Position equipment in the cabinet to provide access to all terminal strips and equipment from the front without removing other equipment. Provide an unobstructed view of all equipment having visual indicators. Place all equipment in an upright position and not on top of other equipment.

Provide Department approved controller cabinet with adequate room for all necessary equipment and cable. Provide removable 5/8-inch handle designed for the door(s) and a full height, continuously welded, piano hinge. Continuously weld all joints of the cabinet. Mount a fluorescent light (suitable for freezing temperatures) inside the front and back of the cabinet automatically turning on when the cabinet door is open. Provide a pull-out shelf to double as a storage container for wiring diagrams, plans, and timing sheets.

Provide a twist lock receptacle and transfer switch for power provided by an emergency generator during power outages. Access to the twist lock receptacle and the transfer switch thorough the use of a locked police door using a No. 2 key or standard police key.

Provide door with continuous stainless steel door hinge on right side, door stop at 90 degrees and 180 degrees, ± 10 degrees, for all doors over 22 inches wide, auxiliary door for access to police panel, pocket for prints.

- Hardware—Vandal and corrosion resistant.
- Finish—Natural with external welds free of irregularities and a maximum bead height of 1/8 inch.
- Gaskets—Neoprene, attached with an oil resistant adhesive.
- Mountings—As indicated, pole or foundation.
- Locks—Brass, tumbler type for main door and standard police lock for auxiliary door; two keys for each lock.
- Latching Mechanism—One point-through mechanism for doors less than 22 inches in width; three point-through mechanism for doors 22 inches or wider.
- Interior—Shelf-mounted equipment, unless rack or panel-mounted.
- Test Pushbutton Panel—One pushbutton to each input for simulated detector operation of vehicles and pedestrians with type and phase permanently labeled on panel. Mount panel on inside of door.

Back panels, wiring and terminals for maximum phase capability of solid-state controller unit, load switch sockets as required and as follows:

Controller Unit	Load Switch Sockets	
	Minimum Number	Maximum Number
Pretimed	6	As required
2 Phase Actuated	4	As required
2-4 Phase Actuated	8*	12
2-8 Phase Actuated	12*	20

* Provide a minimum of two unused sockets per unit.

1.f.2 Environmental Controls.

- Ventilation—Weatherproof vents of minimum 4 square inches area in the lower part of the door or cabinet.
- Filter—Cover vents with full perimeter frame with a disposable filter securely held in place.

1.f.3 Solid-State Equipment.

- Fan—Capacity; 100 cubic feet/minute minimum.
- Fan Thermostat—Line-voltage type, adjustable from 91F to 149F, with fan set to turn on at 43F.

2. Type 170 Controller Unit.

2.a Standards. The manufacturers of all component parts and hardware are to be from a Bulletin 15 manufacturer.

Comply with current Type 170 controller industry standards.

2.b Controller Requirements.

- Provide controller chip as directed by the Representative.
- Provide a 170 microcomputer having a vertical board design with separate input and output boards.
- Include ability to accept a contact closure (or open controller output) to reset clock on controller at a predetermined hour each day (typically 2:00 AM).
- Equip the controller with four serial communication ports, each capable of communicating at speeds up to 9600 bits/sec. The port assignments to be as follows:
  Port 1: Internal Modem
  Port 2: PC Laptop Connection
  Port 3: Conflict Monitor Communication
  Port 4: Future Use
- Provide 412C prom module.
  - Data retention in the absence of Controller Voltage (Vcc).
  - Data is automatically protected during power loss.
  - Directly replaces 8K x 8 volatile static RAM or EEPROM.
  - Unlimited write cycles.
  - Low-power CMOS.
  - Over 50 years of data retention.
  - Standard 28-pin JEDEC pinout.
  - 200 ns read access time.
  - Read cycle time equals write cycle time.
  - Lithium energy source is electrically disconnected to retain freshness until power is applied for the first time.
  - Industrial temperature range of -40F to 185F.
- Furnish all controller assemblies so that the controller returns to normal operation from cabinet flash automatically.
- An approved plug-in hand control with cord is required in all cabinets, and a method to switch the signal controller from automatic to manual control.
- Provide for automatic return to flashing operation when lost electrical service has been restored.

- The "Flash Sense", "Stop Time", and "Cabinet Door Open" functions to be optically isolated but capable of operating without a Model 242 DC isolator.
- Provide pre-wired input file with a minimum of eight inputs, and equipped with Model 242 Two-Channel DC isolators. Supply the required number of Model 242 DC isolators, plus one spare, for each intersection. Also provide slots and internal wiring for two future model 224 four-channel loop sensing units.
- Provide Fiber Modem (as specified per the system) for the communication between local controller and master controller. Clean and connect fiber-optic cable to the new controller using procedures described in current Department and industry guidelines – FOA.
- Provide software as directed by special provision unless provided by the municipality.

2.c Conflict Monitor. Provide Model 170 card-mounted conflict monitor capable of communicating with the 170 Microcomputer. The conflict monitor, when polled by a system compatible 170 Microcomputer, will return information including, but not limited to, the status of all monitored inputs and events stored in non-volatile memory. It will also monitor the absence of a red indication along with normal conflicts, and perform all the functions required by a Model 210 conflict monitor, including the following features:

- Monitoring the absence of signal on any channel.
- Include three preemption inputs to disable red monitoring.
- Include red signal monitoring interface through front panel connector.
- Detect simultaneous display of GREEN and YELLOW on a channel.
- Detect simultaneous display of GREEN and RED on a channel.
- Detect minimum YELLOW display following a GREEN on a channel.
- Store of up to 64 events.
- Inform 170 controller of a resetting via a communication port.
- Monitor incoming line voltage.

A minimum of one input channel for each load switch socket as specified in Section 1104.03(b)2.e.

2.d Flasher Unit.

- TS 1, Section 8, Solid State Flasher.
- TS 2, Section 2.6, Flasher Tests.
- TS 2, Section 6.3, Solid-State Flasher.

2.e Load Switches.

- TS 1, Section 5, Solid-State Load Switches.
- TS 2, Section 2.5, Load Switch Tests.
- TS 2, Section 6.2, Three-Circuit Solid State Load Switch.
- Provide Type 170 load switch.
- Provide a minimum of twenty pre-wired load switch positions as shown on the approved plans.
- Provide a load switch of a repairable, modular type construction.
- Provide a minimum of four flash transfer relays.
- Operational Features: Provide LED indicators to display operation. Isolate signal load from load switch input using optic couplers. Furnish a minimum of one load switch for each of the following active controller unit functions:
  - Vehicle Phase.
  - Overlapping Vehicle Phase.
  - Pedestrian Phase.

2.f Cabinet. Minimum size as shown on the approved plans and as follows:

Position equipment in the cabinet to provide access to all terminal strips and equipment from the front without removing other equipment. Provide an unobstructed view of all equipment having visual indicators.

Place all equipment in an upright position and not on top of other equipment.

Provide Department approved Type 170 controller cabinet with adequate room for all necessary equipment and cable. Provide removable 5/8-inch handle designed for the door(s) and a full height, continuously welded, piano hinge. Continuously weld all joints of the cabinet. Mount a fluorescent light (suitable for freezing temperatures) inside the front and back of the cabinet automatically turning on when the cabinet door is open. Provide a pull-out shelf to double as a storage container for wiring diagrams, approved plans, and timing sheets.

The latching mechanism will be a three point draw roller. Equip the large cabinet door with a spring lock, which can be opened only by a key. Equip the smaller compartment door with a similar spring lock, which can be opened only by a standard police box key.

An approved plug-in hand control is required in all cabinets and a method to switch the signal controller from automatic to manual control.

Provide a twist lock receptacle and transfer switch for power provided by an emergency generator during power outages. Access to the twist lock receptacle and the transfer switch thorough the use of a locked police door using a No. 2 key or standard police key.

3. Type 2070 Controller Unit.

3.a Standards. The manufacturers of all component parts and hardware are to be Bulletin 15 approved.

Comply with current Type 2070 controller industry standards.

3.b Controller Requirements.

- Program module as approved by Representative
- Communications module as approved by Representative
- Processor module as approved by Representative
- Power supply module as approved by Representative
- The 2070 microcomputer is to have a vertical board design with separate input and output boards.
- Include ability to accept a contact closure (or open controller output) to reset clock on controller at a predetermined hour each day (typically 2:00 AM).
- Equip the controller with four serial communication ports and one Ethernet port, each capable of communicating at speeds up to 9600 bits/sec. The port assignments are to be as follows:
  Port 1: Internal Modem
  Port 2: PC Laptop Connection
  Port 3: Conflict Monitor Communication
  Port 4: Future Use
  Port 5: Ethernet

- Provide 412C prom module.
  - Data retention in the absence of Controller Voltage (Vcc).
  - Data is automatically protected during power loss.
  - Directly replaces 8K x 8 volatile static RAM or EEPROM.
  - Unlimited write cycles.
  - Low-power CMOS.
  - Over 50 years of data retention.
  - Standard 28-pin JEDEC pin out.
  - 200 ns read access time.
  - Read cycle time equals write cycle time.
  - Lithium energy source is electrically disconnected to retain freshness until power is applied for the first time.
  - Industrial temperature range of -40F to 185F.

- Furnish all controller assemblies so that the controller returns to normal operation from time clock flash automatically.

- An approved plug-in hand control with cord is required in all cabinets, and a method to switch the signal controller from automatic to manual control.
- Provide for automatic return to flashing operation when lost electrical service has been restored.
- The "Flash Sense", "Stop Time", and "Cabinet Door Open" functions to be optically isolated but capable of operating without a Model 242 DC isolator.
- Provide pre-wired input file with a minimum of eight inputs, and equipped with Model 242 Two-Channel DC isolators. Supply the required number of Model 242 DC isolators, plus one spare, for each intersection. Also, provide slots and internal wiring for two future model 224 four-channel loop sensing units.
- Provide Fiber Modem (as specified per the system) for the communication between local controller and master controller. Clean and connect fiber-optic cable to the new controller using procedures described in current Department and industry guidelines –FOA.
- Provide software as directed by special provision unless provided by the municipality.

3.c Conflict Monitor. Provide Model 2070 Malfunction Management Unit. Exception: When mounted in a 336 cabinet provide conflict monitor using cabinet bus interface.

Equip the conflict monitor with a programmable serial interface capable of communicating at a speed of up to 1200 bits/sec with the 2070 Microcomputer. The conflict monitor, when polled by a system compatible 2070 Microcomputer, is to return information including, but not limited to, the status of all monitored inputs and events stored in non-volatile memory. Also monitor the absence of a red indication along with normal conflicts, and perform all the functions required by a Model 210 conflict monitor, including the following features:

- Monitoring the absence of signal on any channel.
- Include three preemption inputs to disable red monitoring.
- Include red signal monitoring interface through front panel connector.
- Detect simultaneous display of GREEN and YELLOW on a channel.
- Detect simultaneous display of GREEN and RED on a channel.
- Detect minimum YELLOW display following a GREEN on a channel.
- Store of up to 64 events.
- Inform 2070 controller of a resetting via a communication port.
- Monitor incoming line voltage.

A minimum of one input channel for each load switch socket as specified in Section 1104.03(b)3.e.

3.d Flasher Unit.

- TS 1, Section 8, Solid State Flasher.
- TS 2, Section 2.6, Flasher Tests.
- TS 2, Section 6.3, Solid-State Flasher.

3.e Load Switches.

- TS 1, Section 5, Solid-State Load Switches.
- TS 2, Section 2.5, Load Switch Tests.
- TS 2, Section 6.2, Three-Circuit Solid State Load Switch
- Provide Type 2070 Switch Packs
- Provide a minimum of eight, maximum of twenty pre-wired switch positions as shown on the approved plans.
- Provide a switch pack is to be of a repairable, modular type construction.
- Provide a minimum of four flash transfer relays.
- Operational Features: Provide LED indicators to display operation. Isolate signal load from switch pack input using optic couplers. Furnish a minimum of one switch pack for each of the following active controller unit functions:

- Vehicle Phase.
- Overlapping Vehicle Phase.
- Pedestrian Phase.

3.f Cabinet. Section 1104.03(b)2.f

(c) Controller Hardware.

1. Relays.

1.a Light Duty Relay. Mounted in a clear, plastic cover, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Logic, Preemption or Interconnection.
- Voltage—115 V (ac) or 24 V (dc).
- Switch Type—TPDT or DPDT.
- Contact Rating—2 A.
- Contact Material—Fine Silver or Silver Alloy.

1.b Heavy Duty Relay. Mounted in a clear, plastic cover, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Continuous Duty-Transfer of signal indications from normal operation to flashing and the reverse.
- Voltage—95V to 135 V (ac), 57Hz to 63 Hz.
- Switch Type—DPDT.
- Contact Reading—20 A.
- Contact Material—Fine Silver or Silver Alloy.
- Standard Socket—8 Pin, Jones Type.

1.c Dial Transfer. Mounted in a clear plastic cover, permanently marked to indicate coil voltage rating, and as follows:

- Usage—Dial Transfer.
- Voltage—95-135 V (ac), 57 to 63 Hz, 9 W.
- Switch Type—TPDT Electric Latching (two external poles), DPDT Mechanical Latching.
- Contact Rating—1 A.
- Contact Material—Fine Silver or Silver Alloy.
- Standard Socket—Plug, interchangeable with furnished base.

2. Cable Terminal/Harness Assembly. For wiring the cabinet, including connections to the electrical load center, police panel switches, signal load switches, signal cable terminals, controller unit, conflict monitor, detectors, and relays, and as follows:

- Wiring—Arrange and lace or enclose in a raceway or in plastic tubing.
- Terminal Blocks—Barrier-type, with marker strips and nickel-plated brass screws, 8-5/16-inch minimum for detector leads, 10-5/16-inch minimum for signal leads, rated for 20 A at 1000 V (rms).

3. Electrical Load Center.

3.a Breakers and Receptacles.

- Circuit Breakers—15 A minimum, flashing circuit and duplex receptacle. 15 A minimum, traffic control equipment.
- Duplex Receptacle—NEC-Type, Ground Fault Interruptor, with test buttons. 15 A minimum.

3.b Radio Frequency Interference (RFI). UL-Listed, RFI filter, according to NEMA standard testing procedures, TS-2 chapter 5, and as follows:

- Line Voltage—95 V to 135 V (ac).
- Line Frequency—200kHz to 75MHz with minimum attenuation of 50dB.
- Line Current—125% of the total connected load, 30 A minimum.
- Operating Temperature— -29F to 165F.
- Insulation Resistance—6,000 megaohms.
- Line to Ground Rating—1500 V (ac), one minute.
- Line to Line Rating—1450 V (dc), one minute.
- Humidity Range—5 % to 95 %, relative.
- Overload—360 A, for 8 minutes.

3.c Surge Protection. Provide surge protection that has multi-strike capability, UL listed, and line to neutral clamping voltage to be no more than 340 V at 20,000 amps. Filtering surge protector is not to exceed 3.5 inches x 6.0 inches x 2.5 inches, not including studs or mounting flange. Spark gap arrestors are not allowed. All surge protection devices must be approved. The cabinet and content must, as an assembly, pass all NEMA TS-2 voltage spikes test for the AC line.

• Peak Current (8 x 20 ms)	20,000 Amps
• Life Test	5% change
• (Voltage clamp before and after 25 surges of 20 kA waveshape)	
• Clamp voltage	280 V type @ 20 kA
• Response time	voltage never excess 280 V during surge
• Continuous Service Current (120 VAC, 60Hz)	20 Amps maximum
• Operating Temperature	-40F to 185F

Provide surge suppressor that is UL listed and has dual pair (four wire) module implementing three stage hybrid technology or equivalent type as approved by the Representative, for communications cable to 10 kA (2500 A per line).

• Peak Surge Current (10 times):	
o 8 x 20 ms	10 kA
o 10 x 700 ms	500 A per line
• Life Expectancy:	
o 8 x 20 ms	>100 occurrences
o 10 x 700 ms	
• Response time	< 1 nanosecond
• Technology	SAD Hybrid
• Operating Temperature	

3.d Grounding Requirements. Provide each controller with its own grounding rod in addition to the other grounding requirements for signal supports. Grounding and Grounding Rods will be installed in accordance with the Standard Drawings and as follows:

Place two grounding rods at the base of the controller. Test all grounding rods used for controllers, mast arms, and supports for their resistance to ground in accordance with the NEC; with resistance

less than 25 ohms. For grounding rods failing the above-mentioned test, relocate the grounding rod to a suitable location approved by the Representative. When suitable, place a grounding grid utilizing shielded copper wire and grounding rods at each corner, around the intersection. Documentation regarding grounding resistance and as-built plans of grounding grid must be verified by the Representative.

4. Police Panel. Furnish with the following switches:

- Auto—Flash
- Lights (ON—OFF)
- Auto—Manual

Provide hand control cable in panel.

5. Time Clock.

5.a Solid-State. Enclosed in an electrical-shockproof housing, conforming to the following requirements:

- Input Voltage—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Output Voltage—95 V to 135 V (ac), 57Hz to 63 Hz.
- Output Current—5 A.
- Output Circuits—As required.
- Output Setting Limit—10 minutes.
- Skip-Feature—7 day.
- Carryover—24 hours minimum.
- Clock Setting Limit—1 second.
- Time Sets—One on-off/day/circuit.
- Temperature— -29F to 165F.
- Transient Immunity—Varistor.
- Humidity—5% to 95% relative.
- Daylight Savings Time—Automatic transfer.

5.b Time-of-Day Clock, Global Positioning System (GPS).

- A system consisting of a GPS receiver and base unit for mounting in traffic controller enclosure.
- This system must have a contact closure (or open controller output) to reset clock on controller at a predetermined hour each day (typically 2:00 AM).
- They will require Daylight Savings Time (DST) adjustment and zone adjustment entries as well as time setting.
- Once programmed, the base unit will send signals or messages to the traffic light host controller over the contact closure.
- The base is to be equipped with a LED to indicate the unit's status during operation.

1104.04 SYSTEMS AND COMMUNICATIONS—

(a) Time-Based Coordinator Unit.

1. Type. Internal to controller unit or as required to interface with controller unit not having internal time-based coordination capability. If being placed in an existing traffic signal system, make compatible with the existing time-based coordinators in that system.

2. NEMA Standards.

- TS 1-2.1.1, Operating Voltage, Frequency, and Power Interrupt.
- TS 1-2.1.2, Voltage.
- TS 1-2.1.3, Frequency Range.
- TS 1-2.1.5, Temperature and Humidity.
- TS 1-2.1.6, Transients, Power Service.
- TS 1-2.1.12, Vibration.
- TS 1-2.1.13, Shock.
- TS 1-13.2, Electrical Limits of Input/Output.

3. Provisions for Timing Plans.

- Storage Capability (minimum)—Nine, settable, timing programs; one dedicated free-operation program; and three control programs.
- Settable Program Positions (minimum)—One Offset; One Cycle; One Split
- On/Off Output Switch—One per control program.
- Program Assertion—Turn-off previous settable or free programs at the assertion of any of the settable or free, operational programs.

4. Cycle.

- Number—Three, minimum.
- Duration—Settable range of at least 30 seconds to 250 seconds.
- Increments—5 second maximum.

5. Clock/Calendar.

- Resolution—1 second.
- Selectable Programs—Day of week/hour/minute/second
- Number of Changes—50 minimum per day.
- Daylight Savings Time—Automatic transfer.
- Accuracy—±0.005 (50 ppm)% of clock calendar time, with respect to real time.

6. Display. A type providing the functionality of programming and obtaining the following: day of week, hour, minute, second, program in effect, and setting stored or entered for storage.

7. Uninterruptible Power Supply (UPS). Sections 1104.05(i) and 954.4(m)

8. Inputs.

- Power Requirements—95 V to 135 V (ac), 57 Hz to 63 Hz.
- Minimum Number and Type—Eight green-signal inputs at 24 V (dc), negative true.
- Keyboard—Front panel mount.
- Transfer Function—Input program from other unit.

9. Outputs. Section 1104.04(b)

10. Program Transition. Pretimed Controller Units

- Dwell in coordinated phase walk.
- Dwell not to exceed 25% of operating cycle.
- Dwell in called-cycle when cycle transfer occurs due to program change.
- Program transfer, not to exceed four cycles.

(b) Master Controller Assembly. In accordance with Section 952 and as follows:

1. Master Controller Unit (Solid-State, Pretimed). Capable of functioning as an intersection controller or as a master controller to supervise other intersection controllers and as follows:

- Output Circuits—Ground true.
- Time Switch—For functions.
- Manual Pushbutton—For sync function with master removed.

2. Conflict Monitor. Section 1104.03(c)

3. Flasher. Section 1104.03(c)

4. Relays. Section 1104.03(c)

5. Load Switches. Section 1104.03(c)

6. Cable Terminal/Harness Assembly. Section 1104.03(c)

7. Electrical Load Center. Section 1104.03(c)

8. Police Panel. Section 1104.03(c)

9. NEMA Cabinet. Section 1104.03(c)

(c) Coordination Unit. In accordance with Section 952 and as follows:

1. Solid-State. Capable of coordination up to an eight-phase, dual-ring, solid-state, actuated controller unit and as follows:

1.a Cycle.

- Length—As indicated, in 1-second increments.
- Force-Off—Ensure the force-off command is directed to correct phase.
- Cycle and Split Transfer—At 0% point in local cycle.
- Offset Transfer—With pedestrian control, transfer in “green/walk” interval. With nonpedestrian control, transfer in “green.” Transfer to occur in a maximum of three cycles with no more than 17% change in any one cycle.

1.b Interface. NEMA TS 1, Section 13.

1.c System Interconnection.

- Type—Standard, seven-wire, positive subsystem.
- Function Requirements—95 V to 135 V (ac), 57 Hz to 63 Hz with isolated ground.

1.d Environment. NEMA TS 1, Section 2

(d) Closed Loop Signal System.

1. Master Controller. As directed by the Representative, provide a master controller or field-hardened CPU compatible with the closed loop signal system software.

2. Computer System. Provide a computer system to host a central system software and user interface.

3. Software. Furnish two versions of closed loop system software along with appropriate manuals. Provide software capable of operating in latest Windows operating system or updated version.

(e) Radio Communications System. Radio communication system consisting of a transmit/receive radio unit, coaxial cable, coaxial cable surge protection, antennas, mounting hardware, and antenna grounding kit. Use unlicensed frequency bands for radio units unless a licensed band has been preapproved by the Representative. Provide all necessary antennas, cables, jumpers and lightning protection, but not be limited to the following requirements:

- Provide omni antennas having a minimum gain of 8dbi and directional antennas 12dbi unless stated higher in the approved drawings. Provide antennas having 50 ohms impedance and voltage standing wave ratio (VSWR) less than 1.5:1.
- Provide coaxial cable having 50 ohms impedance. Provide a minimum 1/2 inch coaxial cable with N-type connections. Smaller 1/4 inch flexible jumpers are allowed inside enclosures. Provide external antenna connectors that are weatherproofed with an approved rubber mastic tape.
- Provide serial radio units with a minimum data throughput of 115kbps and for Ethernet radio units 1Mbps. Use radio units having built-in setup and diagnostic capabilities. Have a minimum receiver sensitivity -106dbm for serial radio units and -92dbm for Ethernet. Output impedance of 50 ohms on all radio units. Provide radio units meeting the following approval agencies (FCC, IEC, ANSI, and UL).

(f) Cable.

1. Control Cable. Furnish control cable, for field devices not requiring shielded conductors, conforming to IMSA Specification 19-1 or 20-1 for cable in conduit and IMSA Specification 20-3 for aerial cable. Provide stranded conductors, 14 AWG, minimum.

2. Communication Cable. Furnish communication cable, for signal controller telecommunications, conforming to IMSA Specification 19-2 or 20-2 for cable in conduit and IMSA Specification 20-4 for aerial cable. Provide as indicated, stranded conductors, 19 AWG, minimum.

3. Instrument Cable. Provide IMSA certified shielded cable, for filed devices requiring immunity to frequency interference, with three solid 20 AWG conductors and one drain wire and as follows:

- Insulation—Moisture and heat resistant (167F) polyethylene conforming to ASTM D 1248, Type I, Class B, Category 5, Grade E4, 600 V rating applied concentrically about the conductor.
- Color Code—(1) yellow, (1) blue, (1) orange.
- Shield—Mylar/aluminum tape shielding, applied with a nominal overlap of 20%, with the aluminum side in contact with the drain wire.
- Jacket—Polyvinyl chloride, having an average wall thickness of 0.045 inch, conforming to IMSA Specification 19-l, and rated at 176F.
- Electrical—dc resistance of each conductor, less characteristics than 11 ohms per 1,000 feet. Capacitance between each insulated wire and all other less than 48 pF per foot.
- Finished outside diameter—Less than 0.300 inch.

(g) Data Level Protocols for Serial or Ethernet Communications. In accordance with TIA/EIA-568-b, ANSI/TIA/EIA-232, ANSI/TIA/EIA-485 or compatible standards-based protocol for, but not limited to, the following:

- Data Capacity (“Bandwidth”).
- Required Turnaround Time.
- Allowable Latency.
- Allowable Bit Error Rates.
- Data-Level Protocols.
- Testing, including requirements and test plans.

1104.05 ELECTRICAL DISTRIBUTION—

(a) Conduit.

1. Rigid Steel Conduit. Section 1101.09, except may be used for direct burial, and UL-6 Listing for rigid metallic conduit, galvanized inside and outside.

2. Rigid Polyvinyl Chloride Conduit. Section 1101.09 with UL-651 Listing for rigid nonmetallic conduit, and UL-514 Listing for fittings.

3. Cable Pulling Lubricant. Section 1101.12(c)

4. Conduit Sealant. An acceptable duct seal.

(b) Wire and Cable.

1. Signal Cable. 14 AWG minimum, stranded conductors; conforming to IMSA Specification 19-1 or 20-1.

2. Service Wire. 8 AWG minimum wire, Type USE conforming to UL-854 Listing and ASTM B 3 and B 8 for soft, annealed copper.

3. Ground Wire. Bare or insulated (green) copper wire, 8 AWG, conforming to ASTM B 3.

4. Cable Tags. An acceptable type.

5. Cable Ties. An acceptable type.

6. High-Density Polyethylene (HDPE) Conduit. NEMA TC7 Standards and Schedule 40.

7. Polyester Pull Tape. Rated 900 pounds

8. Cable Supports. For span wire installations utilize insulated cable rings and saddles, or other acceptable type support, to secure cable to span wire.

(c) Junction Box. Furnish the type indicated and as follows:

- Precast Junction Box—Section 714
- Steel or Cast-Iron Junction Box—steel or cast iron conforming to the requirements for cast-iron junction box, Section 1101.10.
- Reinforced Plastic Mortar Junction Box—Provide heavy duty junction box with nonskid surface and a watertight connection to the housing. Provide a minimum design load 15,000 pounds with a test load of 22,500 pounds. Place a logo “Traffic Signal” on cover.

(d) Electrical Service.

1. Service Pole. Section 1101.11(a)

2. Service Head. UL-Listed weatherproof service head, for applicable conduit type.

3. Meter Socket. As specified by the utility company.

4. Service Disconnect.

4.a Enclosure. Galvanized steel, aluminum, or stainless steel, with a hinged door having provisions for a padlock and no external handles or switches; conforming to the NEMA Standard for Type 3R, Type 3S, or Type 4.

Provide a brass padlock for outdoor use, with two keys. All padlocks shall be keyed alike.

4.b Main Disconnect. Provide a means for disconnecting the service conforming to NEC.

4.c Fuses. UL-Listed Type K-1, 30 A minimum.

4.d Fuse Block. UL-Listed for K-1 fuses.

4.e Power Line Surge Protector. UL-Listed, rated for a maximum permissible line to ground voltage of 175 V (rms). Clamping voltage not to exceed 250 volts. Provide model with LED to indicate proper functioning of protection for each line.

(e) Wire Connectors.

1. Wire Nuts. Insulated, UL-Listed, with spring insert for applicable wire size and rating of wire insulation.

2. Waterproof Resin Sealer. Insulated, UL-Listed for wire nuts.

3. Terminal Blocks. UL-Listed with twelve-sets minimum to two terminals each, screw-type, rated at a minimum of 600 V, and suitable for the applicable wire size. Connect each set of terminals by means of a removable link. Separate each set of terminals by a molded barrier. Provide a marker strip for terminal identification.

4. Insulated Locking Spade Terminals. An acceptable type.

(f) Grounding Bushings and Lugs.

1. Bushings. UL-Listed for applicable conduit type and size.

2. Lugs. UL-Listed for applicable materials.

(g) Ground Rods With Clamp. Section 1101.11(j)

(h) Generator Adaptor Kit. Facilitate connection to an external power source, a 110 V AC generator.

1. Disconnect Enclosure. Section 1104.05(d)4.a

2. Transfer Switch. Capable of disconnecting the permanent power source and connecting to the emergency power source.

3. Connector Cable Assembly. Sufficient length to allow the attachment of an external power source in accordance with the latest NEC.

4. Surge Protection. Protect the signal controller assembly with line to neutral clamping voltage of no more than 250 V at 20,000 A.

(i) Uninterrupted Power Supply (UPS). Furnish a Battery Backup System (BBS) and full-time double conversion power conditioner UPS compatible with the controller assembly and the following:

- Provide a UL-listed BBS for use with traffic signal equipment.
- Connect to the BBS a standard, readily available RS232 cable.
- Provide batteries that are deep-cycle, scaled prismatic lead-calcium based AGM/VRLA (Absorbed Glass Mat/Valve Regulated Lead Acid).
- Provide a system with minimum 4-hour backup operation.
- Provide all warranty information to the Representative at final acceptance.

(j) Service Receptacle. Provide one duplex Ground Fault Circuit Interrupter (GFCI) receptacle that is only used by service technicians working on the signal controller system. No other internal equipment is to be connected to the service receptacle. Minimum rating 20A.

1104.06 SIGNAL HEADS—

(a) Vehicular Signal Heads.

1. Housings. Bulletin 15 manufacturer.

- Plastic—Opaque polycarbonate resin molding, conforming to ASTM D 3935. Federal yellow in color, except the inside of the visor, will have a non-reflective black finish.

- Aluminum—Finish exterior of aluminum housings as follows:

  Clean and coat surfaces of the signal housing, door, and visor, with an infrared, oven-baked, iron-oxide backing primer, conforming to Federal Specification TT-P-1757B and Federal Specification SSPC-Paint 25.

  Coat finished surfaces, except the inside of the visor, with infrared, ovenbaked, highway yellow exterior enamel, conforming to , according to Federal Standard No. 595B. Finish the inside of the visor with phathalic anhydride, black, synthetic baking enamel, with zero gloss reflectance and conforming to the performance requirements of MIL-E-5557 Enamel Heating Resisting Glyceryl Phathalate, Type 4, Instrument Black.

  Requests for black traffic signal housing require the Bureau of Highway Safety and Traffic Engineering approval.

2. Reflectors. Polycarbonate or aluminum. When the reflector is attached to the door, provide a means by which opening the door disables the indication.

3. Miscellaneous. Furnish cut-away visors unless otherwise indicated. Furnish louvers and backplates as indicated, with a non-reflective black finish.

4. Warranty. Provide all warranty documentation to the Representative at final acceptance.

(b) LED Vehicular Signal Head Modules. Bulletin 15 manufacturer and conforming to the following:

- ITE Standard for “Vehicle Traffic Control Signal Heads, Light Emitting Diode (LED) Circular Signal Supplement”
- ITE “Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement”
- MUTCD

Also, conforming to the regulations, and as follows:

1. Housings. Section 1104.06(a)1

2. Miscellaneous. Section 1104.06(a)3

3. Warranties. Provide all warranty documentation to the Representative at final acceptance.

(c) Optically Programmed Signal Heads. Bulletin 15 manufacturer and conforming to the following:

1. Optical. Incorporate an optical system, using LED modules for the green, yellow, and red signal indications, that limits the visibility zone internally and optically, without the use of hoods or louvers. The projected

signal may be visible or selectively veiled anywhere within 15 degrees of the optical axis.

2. Sections. Provide an integral means for the incremental tilting of each section, from 0 degrees to 10 degrees above and below the horizontal. Unless directed otherwise, assemble vertically-mounted signals with a 4-degree tilt below the horizontal. Provide couplers, serrated locking rings, flanges, gaskets, and other hardware necessary to mate optically programmed signal sections together or to mate with nonoptically programmed sections, all in a secure and weathertight manner. Shop-join the sections. Use corrosion resistant internal hardware.

3. Painting. Section 1104.06(a)1

4. Electrical. Use copper, brass, nickel-plated brass, or phosphor-bronze, electrical-conducting hardware. Furnish lamps that provide luminous intensity of 950 beam candlepower, conforming to the traffic signal manufacturer's specification, rated at a minimum of 6000 hours. Color code the internal wiring. Provide a breaker that disables the indication when the lamp door is opened.

Provide an integral means within each signal face for regulating its luminous intensity between limits, in proportion to the individual background illumination, but not less than 97% of uncontrolled intensity at 1,000 footcandles; and reduce to 15% ± 2% of maximum intensity at less than 1 footcandle, proportionally and instantaneously.

5. Miscellaneous. Furnish cut-away visors. Furnish optical programming material and instructions. Within each section, affix a permanent, conspicuous warning label, advising of possible eye damage and fire hazard from the sun.

6. Warranty. Provide all warranty documentation to the Representative at final acceptance.

(d) Pedestrian Signal Housing. Bulletin 15 manufacturer and conforming to the ITE Standard for "Adjustable Face Pedestrian Signal Heads," the regulations, and as follows:

1. Housings. Section 1104.06(a)1

2. Reflectors. Section 1104.06(a)3

3. Miscellaneous. Furnish cut-away visors, unless otherwise indicated.

(e) Pedestrian Signal Heads-LED Pedestrian Signal Modules. Bulletin 15 manufacturer and conforming to ITE Standard for "Pedestrian Traffic Control Signal Indications –Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules" and the MUTCD. Provide verification from independent laboratory test results.

Also, conforming to the regulations, and as follows:

1. Housing. Section 1104.06(a)1

2. Electrical. Section 1104.06(c)4

3. Luminous Intensity. Meet or exceed the illumination values for the maintained minimum luminous intensity listed in the ITE Standard for "Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules," Section 3 "Photometric Requirement," Subsection 4.1.1.

4. Warranties. Provide all warranty documentation to the Representative at final acceptance.

(f) Pedestrian Signal Heads—LED Countdown Pedestrian Signal Modules. Bulletin 15 manufacturer and conforming to the ITE Standard for "Pedestrian Traffic Control Signal Indications -Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules" and the MUTCD. Provide verification from independent laboratory test results.

Also, conforming to the regulations, and as follows:

1. Housings. Section 1104.06(a)1

2. Electrical. Section 1104.06(c)4

3. Design and Operation. Furnish double overlay or side-by-side message capable of displaying the symbols of a filled UPRAISED HAND (symbolizing DON'T WALK) and a filled WALKING PERSON (symbolizing WALK), and a countdown timer consisting of 2, 7-segment digits constructed of LEDs.

Provide numeric display either integral to, or separate from, the LED countdown pedestrian signal. If the numeric display is a separate component, the message display unit and the LED countdown numeric display unit must be approved as one system.

Provide UPRAISED HAND and WALKING PERSON symbols as solid figures.

4. Countdown Timer Module. Discontinue and make the LED countdown pedestrian signal display go dark immediately if the pedestrian change interval is interrupted or shortened as part of a transition into a preemption sequence.

- Equip the LED countdown pedestrian signal with a screen, visor, or other device to eliminate all phantom conditions.
- Furnish visors if the LED countdown pedestrian signal display will be visible to motorists stopped at a red traffic signal indication facing perpendicular to the display of the LED countdown pedestrian signal.
- Equip the LED countdown pedestrian signal timer to monitor the pedestrian change intervals and automatically adjust for any changes made at the controller.
- Provide a LED countdown timer module with an internal conflict monitor to prevent any possible conflicts between the UPRAISED HAND / WALKING PERSON signal indications and the time display. When the steady UPRAISED HAND is illuminated, make it impossible to display any number other than zero (0).

5. Warranties. Provide all warranty documentation to the Representative at final acceptance.

(g) LED Lane-Use Traffic Control Signal Heads. Bulletin 15 manufacturer and conforming to the following:

- ITE Standard for “Lane-Use Traffic Control Signal Heads”
- MUTCD
- ITE Standard for “Vehicle Traffic Control Signal Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules,” Sections 3, 5, and 6 (excluding Sections 6.3.2 and 6.4.2, “Maintained Minimum Luminous Intensity”).

1. Housings. Section 1104.06(a)1

2. Warranties. Provide all warranty documentation to the Representative at final acceptance.

(h) Mounting Assembly and Hardware. Furnish signal mounting assemblies and hardware of a type and design that adequately supports the loading indicated and as indicated on the Standard Drawings.

1104.07 DETECTORS—

(a) General.

1. Sealant. Furnish a nonshrinking, flexible sealant for the encapsulation of loop or magnetometer sensor and as follows:

- Number of Components—One or two
- Application Temperature—32F to 100F, unless otherwise specified by manufacturer
- Tack Free—1 hour maximum

- Maximum Curing Time—30 hours
- Permanent Flexibility—to -20F
- Chemically Resistant To:
  De-Icing Chemicals
  Gasoline
  Calcium Chloride (5%)
  Motor Oils
  Hydraulic Brake Fluid

2. Detector Lead In Cable. 14 AWG minimum conforming to IMSA Specification 50-2.

3. Card Rack Assembly.

3.a Power Supply. Furnish a switching-type power supply and as follows:

- Input Voltage—95 V to 135 V (ac), 57Hz to 63 Hz
- Output Voltage—24 V ± 0.3 V (dc)
- Minimum Output Voltage—22.8 V (dc)
- Efficiency—70% minimum
- Full Load Current—3 A minimum
- Line Regulation—0.1% over entire input range
- Load Regulation—0.2% from no load to full load
- Ripple Noise—40 mV (p-p) typical, 75 mV (p-p) at full load
- Environmental—NEMA TS 1, Part 2

Provide a front panel incorporating a pilot lamp, test points for monitoring output voltage, and a circuit breaker or fuse. Ground all exterior metal surfaces to the chassis safety ground.

3.b Card Rack. A standard EIA, 19-inch rack for mounting the detector amplifier units, as follows:

- Aluminum front rails, drilled and tapped (10-32), with EIA spacing.
- Aluminum chassis supporting angles, 10 inches deep and 3 inches wide, for mounting on the sides of the controller cabinet.
- Aluminum connector panels, with connector mounting holes, tapped (4-40) on 0.200-inch centers, then mounted to form a cage 19 inches wide, 5 1/4 inches high, and 6 1/2 inches deep.
- Nonmetallic guides and Cinch-Jones No. 50-44A-30M rear connectors, mounted at 1.200-inch spacings.

4. Re-Enterable Splice Kit. Reusable molded body, internal and external hardware, clear polyurethane compound. Provide an appropriate size to accommodate in-line, wye, “x,” butt, and dead-end splicing of cables rated

at 1000 V or less, with outside diameters from 0.25 inch through 2.50 inches. Supply with the following components:

- Two-part transparent mold body of PVC construction, with tongue-and-groove seams and built-in spacer web.
- Two flexible end caps, each with double-stepped cable entry ports to accommodate the many possible splicing configurations.
- Snap-in caps to cap off the fill ports, after compound pouring.
- Strain bars with insulator sleeves.
- Four shield connectors to provide shield continuity, with strain bars for shielded cables.
- Stainless steel base clamps to secure splice body, end caps, and strain bars.
- Re-enterable electrical insulation and sealing compound, capable of continuous operation at 194F, with an emergency overload temperature rating at 266F, a viscosity of approximately 1,100 centipoise at 79F, a gel time of approximately 20 minutes at 73F, and zero growth fungus resistance, according to ASTM G 21.
- An instruction booklet, showing proper installation and re-entry techniques.

(b) Vehicular Detection.

1. Loop Detector.

1.a Loop Sensor. 14 AWG minimum, conforming to IMSA Specification 51-5.

1.b Loop Amplifier, Shelf-Mounted. Self-tuning, loop amplifier, shelf-mounted, enclosed in a shock-proof housing with relay output and one or two channels as indicated, conforming to NEMA TS 1, Section 7.

1.c Loop Amplifier with Timers, Shelf-Mounted. Self-tuning, loop amplifier, shelf-mounted enclosed in a shock-proof housing with relay output and one or two channels as indicated, conforming to NEMA TS 1, Section 11.

1.d Loop Amplifier, Rack-Mounted. Self-tuning, loop amplifier, mounted on an edge-connected, printed circuit board with an electrically isolated solid-state output and two or four channels as indicated, conforming to NEMA TS 1, Section 7.

1.e Loop Amplifier with Timers, Rack-Mounted. Self-tuning, loop amplifier, mounted on an edge-connected, printed circuit board with an electrically isolated solid-state output and two or four channels as indicated, conforming to NEMA TS 1, Section 11.

2. Video Detection System. Provide model approved by the Representative, that is capable of being IP addressable. As indicated on the approved plans and as follows:

Provide catalog cuts to the Representative for approval before ordering the system.

Provide all equipment, connections, software, mounting system, etc. to provide the video vehicular detection for all locations identified on the approved plans.

Provide a video detection system that meets the latest NEMA TS-2 Standards.

Provide mounting system with all required camera mounting hardware, clamps, field wiring, and all remaining hardware necessary to accomplish installations and operation of the video detection device. As necessary, provide multiple units per approach if multiple zones are required and a single unit cannot provide adequate coverage.

Include four channel cards, unless otherwise directed, along with expansion cards. Have adequate

memory to allow for future software and firmware updates. Remove or disable all video recording capabilities. Have all units Ethernet port and IP addressable. Include all incidental cables and power supplies.

Provide sunshield for each camera.

Replace or repair video detection system at no additional expense to the local municipality or the Department if the system fails to function as intended due to faulty work or material defects.

Adjust and realign detection zone settings and provide and install software updates for 1 year after acceptance by the Department.

2.a Video Camera Lens.

- Continuous focus zoom
- Minimum 10X zoom

2.b Housing and Sunshield.

- Sealed waterproof, dust-tight NEMA-4 housing.

2.c Environmental.

- Capable of operating during all hours and under all weather conditions.
- Temperature -30 F to 140 F
- Relative Humidity 0% to 100%

2.d Detection Zones.

- Minimum of four separate detection zones per camera
- Capable of determining which direction of travel, presence calling, pulse calling, delay, extension, sensitivity settings, and channel output.

2.e Cables and Mounting Hardware.

- As per manufacturer's recommendations.

3. Microwave Radar Detection System. Provide Bulletin 15 approved equipment, with mounting assembly, to detect the presence or passage of vehicles in accordance with Sections 1104.01 and 1104.07 and as follows:

- Operating frequency: 10.525 GHz
- Detection Range (minimum): 80 feet
- Capable of operating during all hours and under all weather conditions
- Capable of determining which direction of travel, presence calling, pulse calling, delay, extension, sensitivity settings, and channel output.
- Detection Pattern: Elliptical 50 feet by 25 feet typical at 50 feet
- Hold time: 0.5 to 5 seconds, adjustable.
- Power: 95-135 V (ac), 15 W
- Relay contacts: Form C, rated at 5 amps
- Mounting: As per manufacturers recommendations
- Sealed waterproof, dust-tight NEMA-4 housing.
- Operating temperature: -30 F to 140 F
- Relative Humidity 0% to 100%

4. Digital Wave Radar Detection (DWRD) System. Provide Bulletin 15 approved equipment and in accordance with Sections 956.2, 1104.01, and 1104.07, and as follows:

- Automatically calibrate the detection device
- Detection Range (minimum): 80 feet

- Capable of operating during all hours and under all weather conditions
- Capable of determining direction of travel, presence calling, pulse calling, delay, extension, sensitivity settings, and channel output.
- Mounting: As per manufacturer's recommendations
- Sealed waterproof, dust-tight NEMA-4 housing
- Operating temperature: -30 F to 140 F
- Relative Humidity 0% to 100%

5. Magnetometer Detector.

5.a Magnetometer Sensor. As indicated and as follows:

- Physical Size—Cylindrical housing, nonferrous, moisture-proof, suitable for direct burial in roadway pavement, with no damage due to subsurface stresses, and with a lead-in cable of proper length for hookup.
- Operational—No moving parts and compatible with the magnetometer detector amplifiers furnished.

5.b Magnetometer Amplifier, Shelf-Mounted. Enclosed in a shock-proof housing and as follows:

- Operation—Solid-state design with two independent detection channels in each unit, designed so the sensing element of one channel has no effect on the other.

- Bimodal—Pulse mode—Provides an output closure of 125 ms ± 25 ms duration for each vehicle entering the detection area.

  Bimodal—Presence mode—Continually indicates the presence of a vehicle, until the vehicle leaves the area of detection, at which time the indication is to cease within 100 ms.

- Sensing Elements—One to six magnetometer sensors per channel capability at a distance of up to 3,000 feet between sensor and amplifier.

- Indicators and Switches—Provide on front panel: an LED indicator, sensitive to vehicle detection; fused or circuit breaker overcurrent protection; mode switch, calibration controls; and switch or switch position per channel for disabling the output of a channel and placing a call on a channel.

- Output—Optically isolated Darlington—An opto-isolated, NPN open collector capable of sinking 50 mA at 30 V (dc).

- Connector—MS-3106A20-29P, 17-pin connector with the following pin assignments:

		Channel 1		**Channel 2**
	White	D		T
	Black	E		N
Probe Sets	Red	P		J
	Green	R		S
	Common (-)	B		K
Output	Detect (+)	G		M
	Neutral		A	
ac Power	High		C	
	Chassis Ground		H	

- Power Requirements—Maximum 11 V·A at 105 V to 125 V (ac), 57 Hz to 63 Hz without

originating, nor being susceptible to, electrical transients in excess of the NEMA, TS 1, Section 2.

- Environment—NEMA TS 1, Section 2.

5.c Magnetometer Amplifier, Rack-Mounted. Mounted on an edge connected, printed circuit board for rack-mounting and as follows:

- Physical—Provide a hand pull to facilitate insertion and removal from the rack.
- Operation—Section 1104.07(b)5.b
- Modes—Section 1104.07(b)5.b
- Sensing Elements—Section 1104.07(b)5.b
- Indicators and Switches—Section 1104.07(b)5.b, excluding overcurrent protection.
- Output—Section 1104.07(b)5.b
- Connector—Cinch Jones Number 50-40-A-30M, 22-pin edge connector, with the following pin assignments:

Pin Function

A	dc Ground
B	+24 V (dc)
C	Reset
D	Sensing Element #1 Input
E	Sensing Element #1 Input
F	Control Unit Output #1 (Collector)
H	Control Unit Output #1 (Emitter)
J	Sensing Element #1 Excitation
K	Sensing Element #1 Excitation
L	Equipment Ground
M	Reserved
N	Reserved
P	Sensing Element #2
R	Sensing Element #2
S	Control Unit Output #2 (Collector)
T	Control Unit Output #2 (Emitter)
U	Sensing Element #2 Excitation
V	Sensing Element #2 Excitation
W	NA
X	NA
Y	NA
Z	NA

Connector—Slotted for keying (Between Pins B&C and Pins M&N).

- Power Requirements—Maximum current 300 mA from 33 V to 28 V (dc).

- Environmental—NEMA TS 1, Section 2.

6. Magnetic Detector.

6.a Magnetic Sensor.

- Physical—Cylindrical case, nonferrous, moisture-proof, suitable for burial within rigid nonmetallic conduit, and with a lead-in of sufficient length.
- Operation—No moving parts and compatible with the magnetic-detector amplifier furnished.

6.b Magnetic Amplifier, Shelf-Mounted. Shelf-mounted, enclosed in a shock-proof housing, and as follows:

- Operation—Solid-state design, with one channel in each unit.
- Sensing Elements—One or more magnetic sensor capability at a distance of up to 1,000 feet between the sensor and amplifier.
- Indicators and Switches—Provide on front panel: indicator for detection of a vehicle, fused or circuit breaker overcurrent protection, calibration controls, and a switch or switch position for disabling the output and placing a call.
- Output—Section 1104.07(c)2
- Connector—Relay output—MS3106A-18-1S, Solid-State (Isolated)—MS3106A-8-15W.
- Power Requirements—Maximum power consumption of 2 W at 120 V (ac) and 60 Hz.
- Environmental—NEMA TS l, Section 2.

6.c Magnetic Amplifier, Rack-Mounted. Mounted on an edge-connected, printed circuit board for rack-mounting and as follows:

- Physical—With a handpull to facilitate insertion and removal from the rack. The four-channel, magnetic-detector amplifier in the front panel space of two, two-channel magnetic-detector amplifiers.

- Operation—Solid-state design with two or four independent detection channels in each unit, as indicated, designed that the sensing element of one channel has no effect on the other.

- Sensing Element—One or more magnetic sensors per channel, capable of sensing at a distance of up to 1,000 feet between the sensor and amplifier.

- Indicators and Switches—Section 1104.07(b)5.b, excluding overcurrent protection.

- Output—Section 1104.07(b)5.b

- Connector—Cinch-Jones Number 50-40-A-30M, 22-pin edge connector, with the following pin assignments:

  Pin Function

  A dc Ground
  B +24 V (dc)
  C Not Connected
  D Detector #1 Element
  E Detector #1 Element
  F Detector #1 Output (C)
  H Detector #1 Output (E)
  J Detector #2 Element
  K Detector #2 Element
  L Chassis Ground
  M Reserved
  N Reserved
  R Detector #3 Element
  S Detector #3 Output (C)
  T Detector #3 Output (E)
  U Detector #4 Element
  V Detector #4 Element
  W Detector #2 Output (C)

X Detector #2 Output (E)
Y Detector #4 Output (C)
Z Detector #4 Output (E)

Connector—Slotted for keying
(C)—Collector
(E)—Emitter

- Power Requirements—Maximum of 60 mA per channel from a 24 V (dc) power supply.

- Environmental—NEMA TS 1, Section 2.

6.d Rigid, Nonmetallic Conduit. Section 1104.05

(c) Pedestrian Detectors. Provide Bulletin 15 approved products.

1. Pedestrian Pushbutton. Capable of completing a momentary circuit closure as indicated on the approved plans and as follows:

- General—Furnish a tamper and weatherproof assembly with pushbutton contacts, entirely insulated from the housing and buttons. Use a pushbutton with 2-inch diameter, ADA-compliant, stainless steel non-moving pushbutton and a maximum force of 5 pounds. Furnish sign and mounting assembly as indicated. Conform to the regulations for the sign legend and Section 1103.04 for the fabrication. Use stainless steel hardware to mount the pushbutton assembly.

- Housing—Die-cast aluminum alloy housing, with a curved back or a flat back as required to conform to the mounting surface. Paint the assembly highway yellow, as specified in Section 1104.06(a)1. Provide a rear cable entry.

- Electrical—Provide a switch mechanism consisting of a direct push-type button, with a single momentary contact switch, contacts rated at 10 A minimum, 125 V (ac) for operation at 24 V (dc).

- Latching LED—provide light emitting diode (LED) light with luminous intensity greater than 1200 mcd in ultra bright red color and a viewing angle of 160 degrees that activities only during non-walk phases upon pedestrian actuation and stays on until the beginning of the walk phase.

2. Accessible Pedestrian Signals (APS). MUTCD and the following as included on the approved plans:

- The type of WALK indication as specified (tone or speech)
- The significance of the “extended button press” function
- The requirement for audible and tactile feedback of the pushbutton activation
- Location of pedestrian buttons, pedestrian heads, and speakers
- Orientation of tactile arrow
- WALK indication tone volume (minimum, maximum and amount over ambient)
- Locator tone volume (minimum, maximum and amount over ambient)
- Any requirement for the street name in Braille or raised print
- Latching LED as specified in Section 1104.07(c)1

Furnish APS and hardware that satisfy industry standards. Ensure that there are no sharp edges that could injure a pedestrian.

Supply weatherproof hardware.

(d) Preemption Systems. Provide Bulletin 15 approved model in accordance with Sections 951, 1104.01, and 1104.03, approved plans, and as follows:

1. Optical Preemption. Include preemption devices, mounting and controller hardware, software, connectors, and cables as specified by manufacturer, to provide a functional system.

Provide optical emitter(s) responsive at a minimum distance of 500 feet.

Arrange for demonstration, as directed.

2. Acoustic Preemption. Provide a siren-activated Emergency Vehicle Preemption System. Include all necessary controller unit connectors, panel wiring, and miscellaneous hardware needed with the control cabinet. Provide field confirmation of detection at a minimum distance of 500 feet.

Certify that no false detection can occur. Arrange for demonstration, as directed.

3. Global Positioning Satellite (GPS) Based Preemption. Provide GPS units with a minimum 500 feet radio range at intersections indicated on approved plans, to gain preemption or priority. Provide all hardware and software necessary to provide a functional GPS-Based Preemption System with secure radio communications. Arrange for demonstration, as directed.

CHAPTER 3. PLAN SHEETS AND OTHER CONTRACT DOCUMENTS

3.1 Traffic Signal Plans

3.1.1 Purpose of a Signal Plan

The traffic signal plan is an important document that illustrates the placement (proposed or existing) of the components required for a traffic signal installation. The plan is used for, but is not limited to, the following:

- ✓ The permit process (permit plan)
- ✓ Facilitating the contractor's bid
- ✓ Building the signal (construction plan)
- ✓ Operating/maintaining the signal
- ✓ Signal locates
- ✓ Tort claims/law suits

3.1.2 Traffic Signal Plan

Preliminary and final signal plans for construction projects should conform to the Traffic Signal Design Handbook (Publication 149) and Design Manual-3 (DM-3). As such, the plan should include the following elements:

- ✓ Construction baseline
- ✓ Roadways, shoulders, curbs, curb ramps, sidewalks, islands, inlets, and all utilities
- ✓ Pavement markings
- ✓ Signal supports, controller, junction boxes, signal heads, detectors, pedestrian accommodations, and luminaires
- ✓ Movement, phasing, and sequence chart, including preemption and emergency flashing operation
- ✓ Electrical distribution
- ✓ Structure sizes, location, offsets, and orientation relative to the construction baseline
- ✓ Tabulation of quantities

Traffic signal phasing should conform to Publication 149 and use National Electrical Manufacturers Association (NEMA) numbering protocol. The goal is to use the minimum number of phases possible in order to reduce the accumulative amount of clearance time and thereby improve efficiency. If an exclusive pedestrian phase is used, it may be labeled Phase 9.

It is important that the location of signal supports conform to Publication 149. Specifically, supports for overhead signals and base-mounted controller cabinets should not be breakaway. However, these supports and other rigidly-supported appurtenances should be located as far as practical beyond the edge of the traveled roadway and outside the pedestrian accessible route.

The minimum clearance of any part of the signal equipment and the supports in areas with curbs and speeds of 35 mph or less should be two feet behind the face of the curb. In all other locations, the minimum clearance should be ten feet from the edge of the traveled roadway and a minimum of two feet from the outer edge of any shoulder. If possible, do not place supports on an island.

3.1.3 Traffic Signal Construction Plans

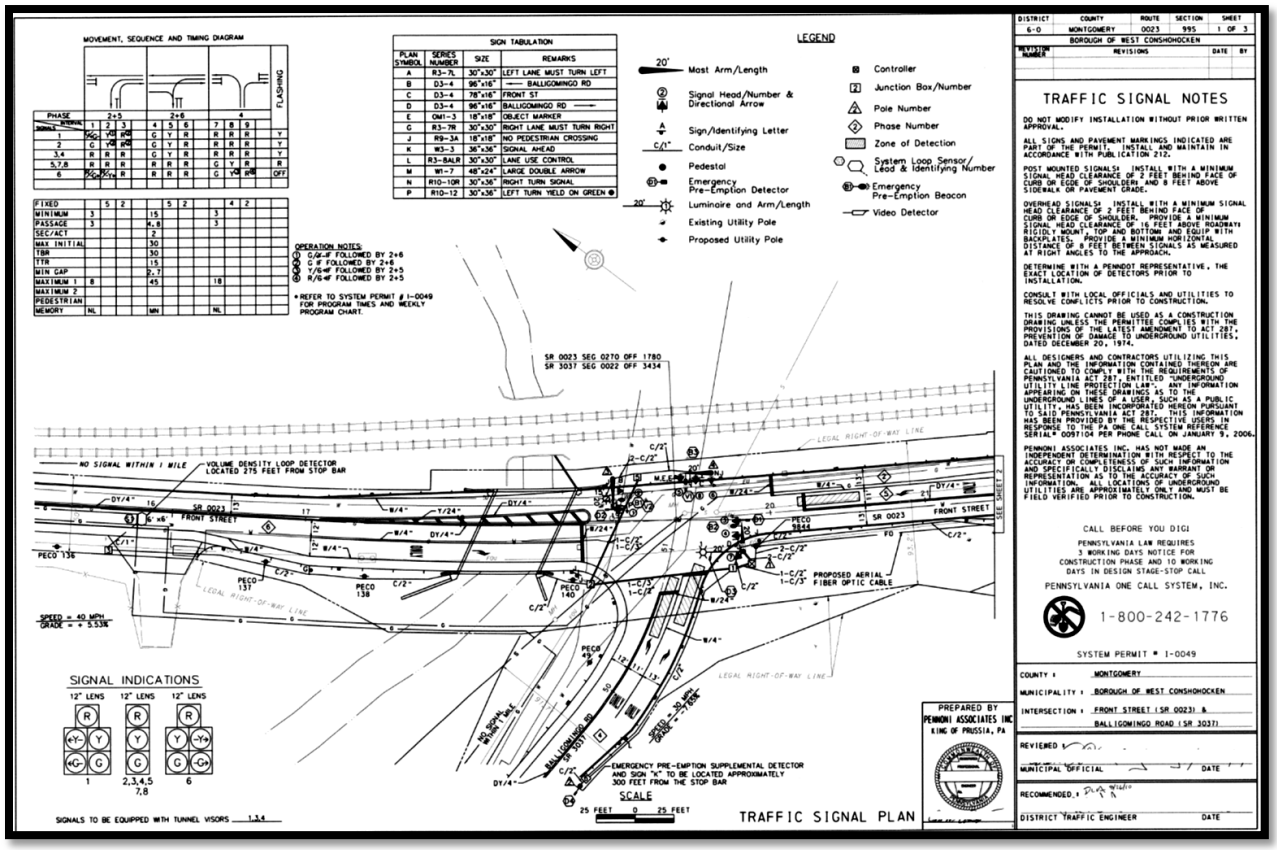
The end product of the pre-construction activities in signal design is the traffic signal construction plans. Supporting the plans and special provisions are the standard design practices, standard details, other applicable national and local standards, and any necessary agreements. Typical information found in a Traffic Signal Plan sheet includes the following:

- ✓ Sign Tabulation
- ✓ Movement, Phasing and Sequence Chart
- ✓ Phasing Diagram
- ✓ Signal Identification
- ✓ Legend
- ✓ Title Block
- ✓ Notes
- ✓ Signal Wiring Diagram
- ✓ Upper Title Block
- ✓ Intersection Layout (for Construction Plans include the following):
    - Existing data as per PennDOT Publication 13M (Design Manual 2)
    - New curbs
    - Pavement markings (only those to be installed by contractor)
    - Supports with pole #'s
    - Signals with #'s
    - Pedestrian signals and pushbuttons with #'s
    - Controller
    - Detectors with #'s
    - Signs with letter designation (only those to be installed by contractor)
    - Junction boxes with #'s
    - Conduit
    - Service location and type
- ✓ Traffic Signal Supports
- ✓ Electrical and Conduit Items
- ✓ Detectors
- ✓ Miscellaneous

Note: The biggest difference between a construction plan and a permit plan is that the construction plan shows the proposed and existing elements. The permit plan simply shows the proposed items.

Exhibit 3-1 shows the first page of a sample construction plan. A copy of all three sheets of this plan is included as a handout at the back of this chapter.

Exhibit 3-1 Sample Signal Construction Plan



3.1.4 Parts of a Construction Plan

Exhibit 3-2 illustrates another construction plan (sheet 1 of 2) with specific areas highlighted for additional explanation.

Exhibit 3-2 Traffic Signal Construction Plan Sheet 1 of 2

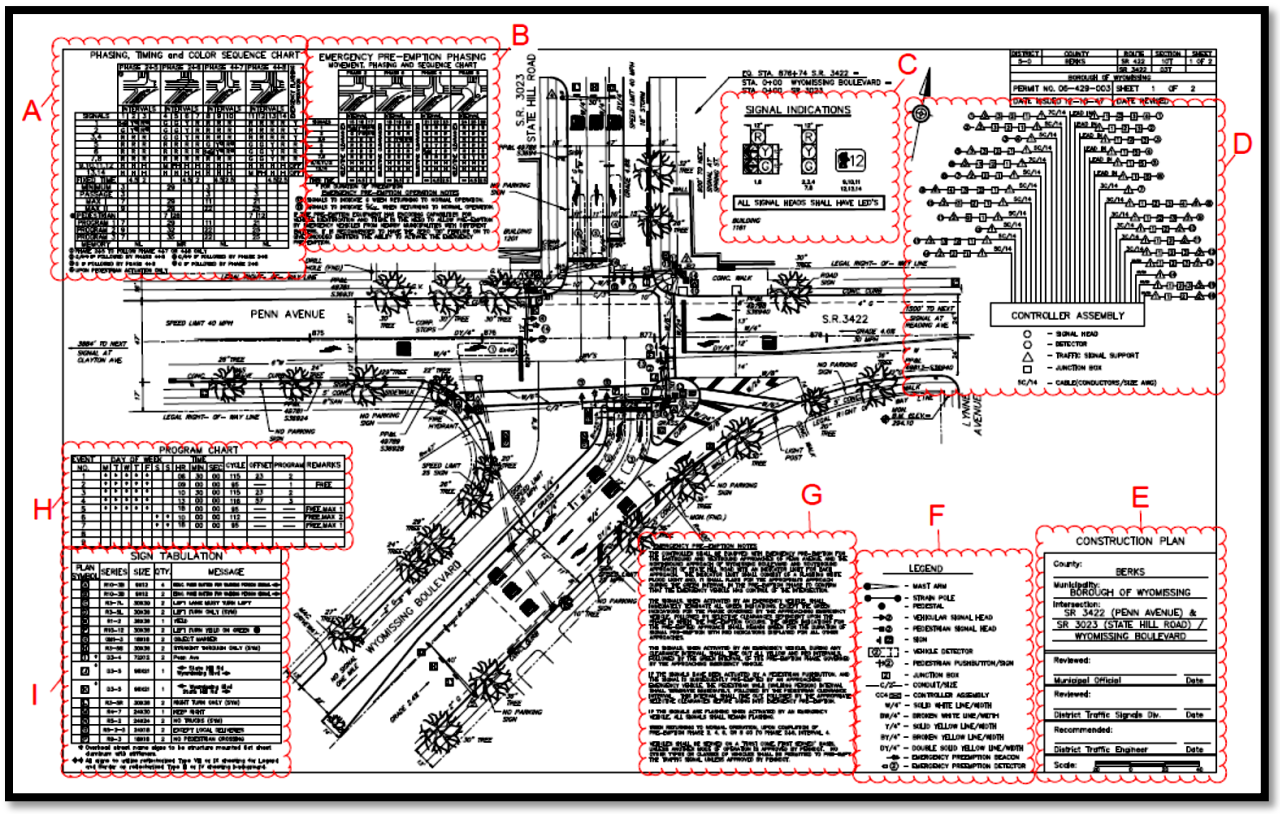


Exhibit 3-3 Movement, Sequence and Timing Chart

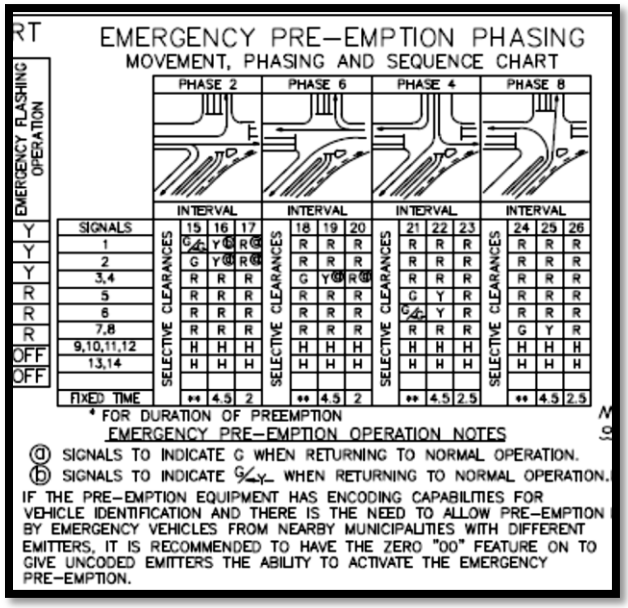
PHASING, TIMING and COLOR SEQUENCE CHART

	PHASE 2+5			PHASE 2+6				PHASE 4+7			PHASE 4+8				EMERGENCY FLASHING OPERATION
	INTERVALS			INTERVALS				INTERVALS			INTERVALS				
SIGNALS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	~~G~~	Y⑤	R⑤	G	G	Y	R	R	R	R	R	R	R	R	Y
2	G	Y⑤	R⑤	G	G	Y	R	R	R	R	R	R	R	R	Y
3,4	R	R	R	G	G	Y	R	R	R	R	R	R	R	R	Y
5	R	R	R	R	R	R	R	G	Y③	R③	G	G	Y	R	R
6	R	R	R	R	R	R	R	~~G~~	Y②	R③	G	G	Y	R	R
7,8	R	R	R	R	R	R	R	R	R	R	G	G	Y	R	R
9,10,11,12	H	H	H	M	FH	H	H	H	H	H	H	H	H	H	OFF
13,14	H	H	H	H	H	H	H	H	H	H	M	FH	H	H	OFF
FIXED TIME		4.5	2			4.5	2		4.5	2.5			4.5	2.5	
MINIMUM	3			29				3			3				
PASSAGE	3							3			3				
MAX I	7			29				11			21				
MAX II	9			29				22			25				
④ PEDESTRIAN				7	26						7	12			
PROGRAM 1	7			29				11			21				
PROGRAM 2	9			32				22			25				
PROGRAM 3	7			35				22			25				
MEMORY	NL			MR				NL			NL				

①PHASE 2+5 TO FOLLOW PHASE 4+7 OR 4+8 ONLY
②~~G~~/~~Y~~ IF FOLLOWED BY PHASE 4+8
③G IF FOLLOWED BY PHASE 4+8
④UPON PEDESTRIAN ACTUATION ONLY
⑤~~G~~/~~Y~~ IF FOLLOWED BY PHASE 2+6
⑥G IF FOLLOWED BY PHASE 2+6

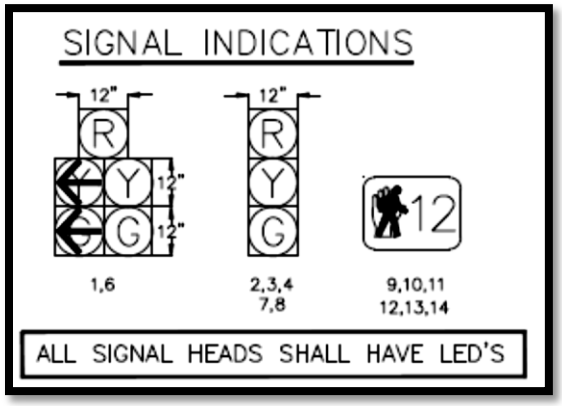
A: This diagram indicates the traffic signal phasing and timing settings.

Exhibit 3-4 Emergency Pre-emption Phasing Chart



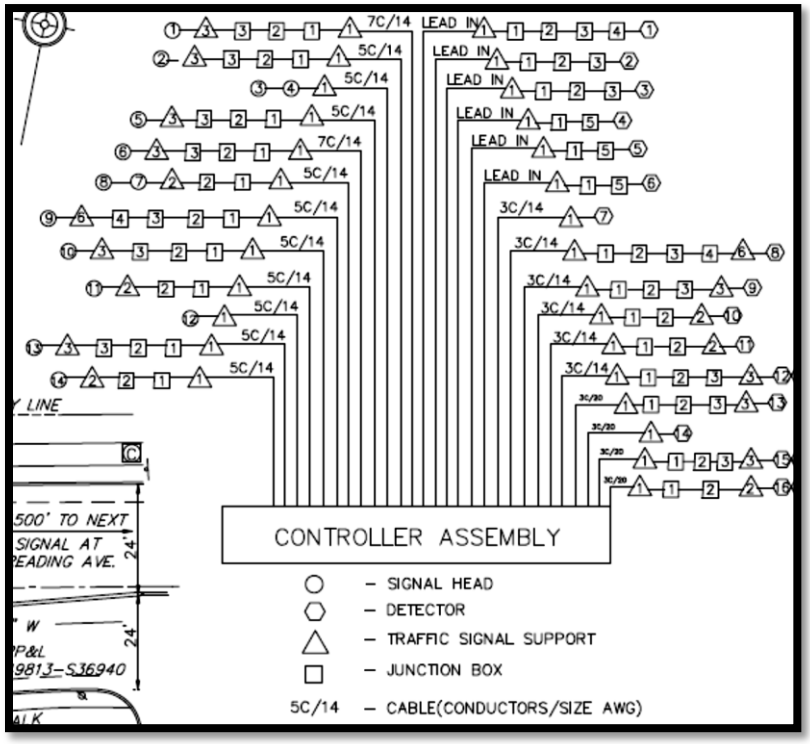
B: This diagram shows the operation of the signal under emergency vehicle pre-emption.

Exhibit 3-5 Signals Legend



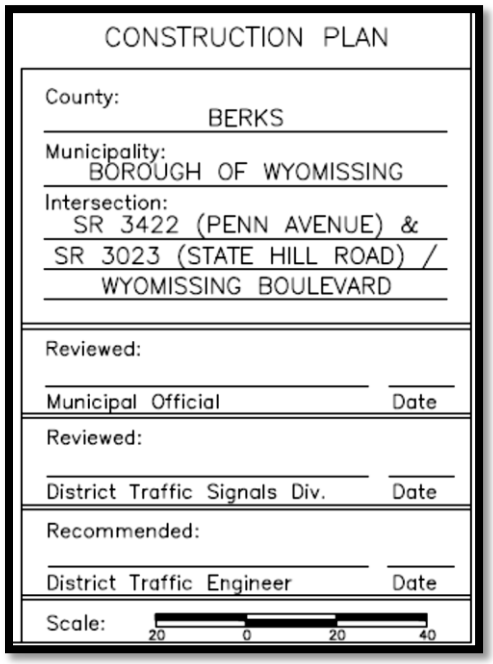
C: This graphic shows the required arrangement of each traffic signal display, its size, and other pertinent information. The numbers below each graphic correspond to the same number on the plan view. It is very important that the traffic signal faces always retain the same special relationships with one another. Notes may also specify the presence of visors, backplates and louvers, and the need for specific types of pedestrian signal heads.

Exhibit 3-6 Wiring Diagram



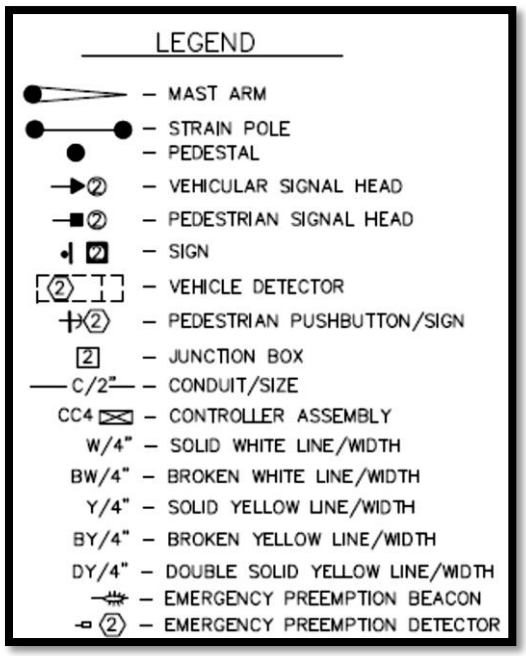
D: This diagram indicates how the traffic signal is wired between junction boxes, poles, signals, and controller. The various symbols used in this chart are also shown at the bottom of the diagram.

Exhibit 3-7 Signature Block



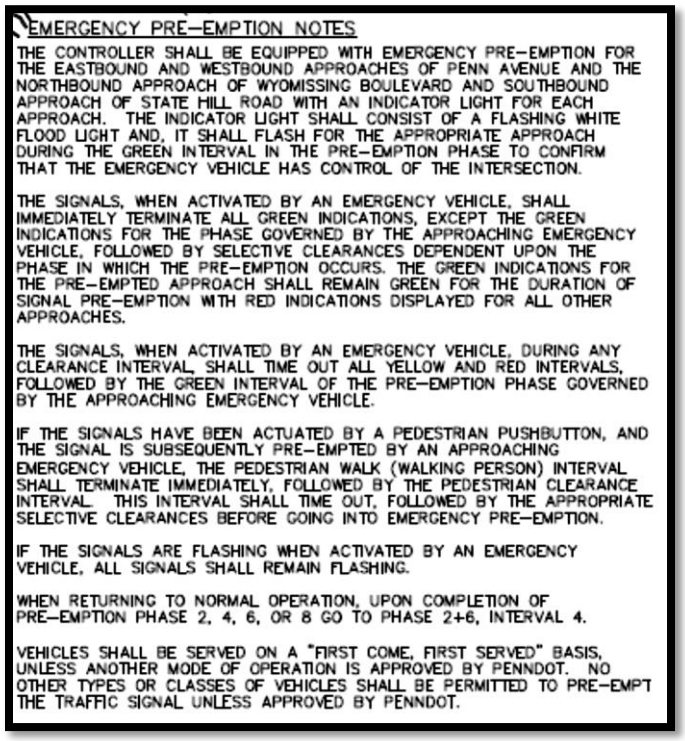
E: The block in the lower right of the plan that identifies and includes intersection name, location, and approval signatures.

Exhibit 3-8 Legend



F: This diagram describes the various icons used on the traffic signal construction plan.

Exhibit 3-9 Emergency Pre-Emption Notes



EMERGENCY PRE–EMPTION NOTES

THE CONTROLLER SHALL BE EQUIPPED WITH EMERGENCY PRE–EMPTION FOR THE EASTBOUND AND WESTBOUND APPROACHES OF PENN AVENUE AND THE NORTHBOUND APPROACH OF WYOMISSING BOULEVARD AND SOUTHBOUND APPROACH OF STATE HILL ROAD WITH AN INDICATOR LIGHT FOR EACH APPROACH. THE INDICATOR LIGHT SHALL CONSIST OF A FLASHING WHITE FLOOD LIGHT AND, IT SHALL FLASH FOR THE APPROPRIATE APPROACH DURING THE GREEN INTERVAL IN THE PRE–EMPTION PHASE TO CONFIRM THAT THE EMERGENCY VEHICLE HAS CONTROL OF THE INTERSECTION.

THE SIGNALS, WHEN ACTIVATED BY AN EMERGENCY VEHICLE, SHALL IMMEDIATELY TERMINATE ALL GREEN INDICATIONS, EXCEPT THE GREEN INDICATIONS FOR THE PHASE GOVERNED BY THE APPROACHING EMERGENCY VEHICLE, FOLLOWED BY SELECTIVE CLEARANCES DEPENDENT UPON THE PHASE IN WHICH THE PRE–EMPTION OCCURS. THE GREEN INDICATIONS FOR THE PRE–EMPTED APPROACH SHALL REMAIN GREEN FOR THE DURATION OF SIGNAL PRE–EMPTION WITH RED INDICATIONS DISPLAYED FOR ALL OTHER APPROACHES.

THE SIGNALS, WHEN ACTIVATED BY AN EMERGENCY VEHICLE, DURING ANY CLEARANCE INTERVAL, SHALL TIME OUT ALL YELLOW AND RED INTERVALS, FOLLOWED BY THE GREEN INTERVAL OF THE PRE–EMPTION PHASE GOVERNED BY THE APPROACHING EMERGENCY VEHICLE.

IF THE SIGNALS HAVE BEEN ACTUATED BY A PEDESTRIAN PUSHBUTTON, AND THE SIGNAL IS SUBSEQUENTLY PRE–EMPTED BY AN APPROACHING EMERGENCY VEHICLE, THE PEDESTRIAN WALK (WALKING PERSON) INTERVAL SHALL TERMINATE IMMEDIATELY, FOLLOWED BY THE PEDESTRIAN CLEARANCE INTERVAL. THIS INTERVAL SHALL TIME OUT, FOLLOWED BY THE APPROPRIATE SELECTIVE CLEARANCES BEFORE GOING INTO EMERGENCY PRE–EMPTION.

IF THE SIGNALS ARE FLASHING WHEN ACTIVATED BY AN EMERGENCY VEHICLE, ALL SIGNALS SHALL REMAIN FLASHING.

WHEN RETURNING TO NORMAL OPERATION, UPON COMPLETION OF PRE–EMPTION PHASE 2, 4, 6, OR 8 GO TO PHASE 2+6, INTERVAL 4.

VEHICLES SHALL BE SERVED ON A "FIRST COME, FIRST SERVED" BASIS, UNLESS ANOTHER MODE OF OPERATION IS APPROVED BY PENNDOT. NO OTHER TYPES OR CLASSES OF VEHICLES SHALL BE PERMITTED TO PRE–EMPT THE TRAFFIC SIGNAL UNLESS APPROVED BY PENNDOT.

G: These notes are specific to the use of the emergency vehicle pre-emption.

Exhibit 3-10 Coordination Plan

PROGRAM CHART

EVENT NO.	DAY OF WEEK M	T	W	T	F	S	S	TIME HR.	MIN.	SEC.	CYCLE	OFFSET	PROGRAM	REMARKS
1	*	*	*	*	*			06	30	00	115	23	2	
2	*	*	*	*	*			09	00	00	95	—	1	FREE
3	*	*	*	*	*			10	30	00	115	23	2	
4	*	*	*	*	*			13	00	00	116	57	3	
5	*	*	*	*	*			18	00	00	95	—	—	FREE,MAX 1
6						*	*	10	00	00	112	—	—	FREE,MAX 2
7						*	*	18	00	00	95	—	—	FREE,MAX 1
8														
9														

H: This table provides cycle, offset, and phase splits (force offs) by time of day when a traffic signal is part of a coordinated signal system. It is generally described in more detail in the Coordination Program sheet that should be included with the Traffic Signal Permit.

Exhibit 3-11 Signing Table

SIGN TABULATION

PLAN SYMBOL		SERIES	SIZE	QTY.	MESSAGE
A		R10-3B	9X12	4	EDUC. PUSH BUTTON FOR WALKING PERSON SIGNAL ←
B		R10-3B	9X12	2	EDUC. PUSH BUTTON FOR WALKING PERSON SIGNAL →
C		R3-7L	30X30	2	LEFT LANE MUST TURN LEFT
D		R3-5L	30X36	2	LEFT TURN ONLY (SYM)
E		R1-2	36X36	1	YIELD
F		R10-12	30X36	2	LEFT TURN YEILD ON GREEN ●
G		OM1-3	18X18	2	OBJECT MARKER
H		R3-5S	30X36	2	STRAIGHT THROUGH ONLY (SYM)
I	*	D3-4	72X12	2	Penn Ave
J	*	D3-5	96X21	1	← State Hill Rd Wyomissing Blvd →
K	*	D3-5	96X21	1	← Wyomissing Blvd State Hill Rd →
L		R3-5R	30X36	2	RIGHT TURN ONLY (SYM)
M		R4-7	24X30	1	KEEP RIGHT
N		R5-2	24X24	2	NO TRUCKS (SYM)
O		R5-2-3	24X18	2	EXCEPT LOCAL DELIVERIES
P		R9-3	18X18	2	NO PEDESTRIAN CROSSING

* Overhead street name signs to be structure mounted flat sheet aluminum with stiffeners.
** All signs to utilize reflectorized Type VIII or IX sheeting for Legend and Border on reflectorized Type III or IV sheeting background.

I: This table indicates the signing required on the permit that is associated with the traffic signal operation.

3.2 Special Provisions

Special provisions for traffic signal projects should be written in accordance with Publication 51, Chapter 1, Section E, Special Provisions. Only items that are not standard Publication 408 items need a special provision. Consult the local PennDOT engineering District and/or Central Office to confirm if a standard special provision exists for an item that may be needed under a traffic signal design project.

For traffic signal items, review Publication 46, Chapter 4 and complete TE-152 "Traffic Signal Proprietary Item Analysis Engineering and Traffic Study" prior to submitting for approval. Also District Traffic Engineer or designee approval is required prior to submitting to the Bureau of Maintenance and Operations.

Publication 51 includes the following language regarding special provisions:

---

1. General. Special Provisions, as part of the bid package, must be written with extreme care. The language used must be clear, concise, complete, correct, and consistent. If the Contractor cannot understand what is wanted, the work cannot be performed correctly. District special provisions are used only when Publication 408 and/or Central Office standard special provision do not cover the construction work or related activities. Provide instructions in sufficient detail to enable the Contractor to determine who is responsible for items of work on the project. Keep in mind that the Special Provisions are legal documents; and each word, sentence, and punctuation mark may come under the scrutiny of a court of law or an arbitration board.
2. Applicable Standard Specifications. All bid packages are governed by PennDOT Specifications Publication 408, unless approval is obtained from the Bureau of Design for specific local government specifications. Standard Special Provision revisions must be approved through the Clearance Transmittal process excluding minor changes. See Appendix A (of Publication 51).
    a. Minor Changes – A proposal Review to Publication 408 or a standard special provision that is minor does not have to be circulated through the CT process. The following is a list of revisions that are considered to be minor:
        - Mandatory change
        - Spelling/typos
        - Improvements to grammar
        - FHWA has given verbal approval
        - Specification that is applicable to 100% State funded projects

These changes will be sent to FHWA. The specification Engineer will send a memo to FHWA and the Pennsylvania Association of Contractors informing them of the minor change.

3.3 Municipal Traffic Signal Specifications

Consideration should be given to municipal traffic signal specifications during the design process. If a municipality has an adopted technical specification for traffic signal installations, the designer and project owner should do their best to accommodate the municipality's needs since the municipality is the permittee and ultimate owner of the traffic signal. Where proprietary equipment is a requirement, follow the process in Chapter 4 of Publication 46. Installation and long-term maintenance costs as well as long-term functionality must be considered when adhering to a municipal specification.

3.4 Coordination of Plans and Specifications

Section 105.04 of Publication 408 indicates the following important information:

"**105.04 COORDINATION OF PLANS AND SPECIFICATIONS**—Perform the work according to the intent of the Plans and Specifications. Do not take advantage of any error on/or omission in the Plans or discrepancy between the Plans and Specifications. In the event such an error, omission, or discrepancy is discovered, immediately notify the Department. Failure to notify the Department will constitute a waiver of all claims for misunderstandings, ambiguities, or any other reasons resulting from the errors, omissions, or discrepancies. If requested, corrections and interpretations necessary for the fulfillment of the Plans and Specifications will be made. Do not use scaled measurements where dimensions on the drawings are given or can be computed.

In case of a discrepancy among the contract documents, the following order of precedence will apply:

(1) Special Provisions

(2) Plans (excluding cited Standard Drawings)

(3) Specifications (other than Special Provisions)

(4) Standard Drawings

If any Special Provisions or information on the Plans conflict with these Specifications, the Special Provisions or information on the Plans will govern. If a conflict exists between any portion of the Plans designed specifically for this project and any portion of the Standard Drawings, the former will govern.

If necessary, the District Executive will determine and order, in writing, any modifications or changes in the Plans, Standard Drawings, or Specifications to update, adjust, accept, or complete the work contemplated by the contract as specified in Section 104.02. Wherever reference specifications or publications are specified, comply with the issue or edition (including interim AASHTO specifications and ASTM tentative designations) in effect on the date bids are opened, unless the date or year of the reference specification or publication is indicated or specified. If there is a conflict between a cited title and a cited section number, the title will take precedence over the section number."

3.5 As-Built (Record) Plans

Once the signal installation has been accepted, as-built (record) drawings need to be made and sent in with the semi-final records. Any part of the installation of the traffic signal that differs from the original design needs to be noted so that others have accurate information as to how it was built. Especially important to note for traffic signal projects are changes in:

- ✓ location of junction boxes
- ✓ vehicle signal heads
- ✓ conduit runs
- ✓ wiring
- ✓ pole locations
- ✓ utilities

The as-built drawings should be clean, neat and accurately prepared. All field changes should be made at the earliest possible date and not trusted to the memory of the recorder.

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CHAPTER 4. MATERIALS AND PRODUCTS

This chapter covers materials and products that are used for traffic signal projects. As noted in Publication 408 (Standard Specifications), Section 106.01:

106.01 GENERAL—Use material complying with the requirements of these specifications. At the pre-construction conference, submit a list of material to be sampled and tested by the Contractor and a list of material to be sampled and tested by the Department.

4.1 Acceptance of Traffic Signal Materials

Acceptance of the following material on construction projects by certification is based on their appropriate Publication 408 (Standard Specifications) reference as shown in **Exhibit 4-1**.

Exhibit 4-1 Acceptance of Materials based on Publication 408

Item	Publication 408 Reference
Traffic Signal Support, Mast Arm	Section 951.2
Traffic Signal Support, Strain Pole	Section 951.2
Traffic Signal Support, Pedestal	Section 951.2
Controller Assembly	Section 951.2
Traffic Signal Systems and Communication	Section 953.2
Electrical Distribution System	Section 954.2
Signal Heads	Section 955.2
Detectors	Section 956.2
Traffic Signals (Manufactured Materials)	Section 1104
Temporary Traffic Control Signals	Section 1124

Additional information on Publication 408, Standard Specifications can be found in Section **2.11** on page **2-9**.

All traffic signal materials should be listed on Form CS-201 (see Section **2.12**). The Districts review and check the form, except for the structural support poles.

In accordance with Department specifications, the engineer may accept certification of materials in lieu of inspection and testing. Therefore, all traffic signal materials included in Publication 408 and the special provisions will be accepted by certification using PennDOT Form CS-201. In addition, those traffic signal materials which must have a Certificate of Approval issued by the Department will be tabulated and submitted to the engineer by the contractor. Acceptance of the materials tabulated for traffic signal items means only that the materials are suitable for the proposed use.

The materials tabulation will be submitted for each project within 3 weeks of the Notice-to-Proceed. This tabulation will include the following project information:

- ✓ State route
- ✓ Section
- ✓ County
- ✓ Prime contractor

Also, provide the following information for each different item of material:

- ✓ Identity of material
- ✓ Manufacturer's name
- ✓ Manufacturer's model number
- ✓ Department's Certificate of Approval Number

Accessories, such as hardware, brackets, supplies, minor devices, etc., necessary for the proper installation of traffic signals but not in Publication 408 or the special provisions are not intended to be submitted for testing and acceptance. However, all load-carrying accessory materials shall be certified as to their structural adequacy for the loads indicated.

Request catalog cuts only if they are necessary to provide clarification of special features or functions of the proposed materials.

The contractor will submit three copies of traffic signal materials tabulation to the District Executive, attention Assistant District Executive, Construction, for review and acceptance. The review by the District staff should include contact with the appropriate municipal officials, if necessary. The District should notify the contractor by letter of the acceptance or rejection of his submission. If rejected, indicate the reason in the letter.

4.2 Traffic Signal Product Approvals

The Bureau of Maintenance and Operations (BOMO) issues a Certificate of Approval (COA) to manufacturers authorizing the sale of specific electrically-operated traffic signal equipment. Contractors are responsible to tabulate a list of the proposed equipment within three weeks after the Notice-to-Proceed, and to submit the list to the Department. The BOMO also approves standard loadings for traffic signal supports, but shop drawings are submitted and design calculations are required for non-standard loadings.

Districts should accept materials when accompanied by a certification stating compliance of the material to the appropriate specification.

Three copies of warranties, guarantees, instruction manuals, wiring diagrams, field wiring diagrams, and parts lists are required and one copy of each should be retained as follows:

- ✓ Department file
- ✓ Municipal file
- ✓ Retained in the controller cabinet
- ✓ Publication 35, Bulletin 15 information

4.2.1 Bulletin 15 Approval Process

The Product Evaluation Application Form (CS-4170, see **Exhibit 2-8**) is the means to submit products for consideration of approval and listing in Bulletin 15. The Product Evaluation Application requires company information, product description and technical information, and quality control plan information. The instructions for completing the Product Evaluation Application address eligibility requirements and detail the product evaluation process.

The following entities are eligible to apply for Bulletin 15 approval:

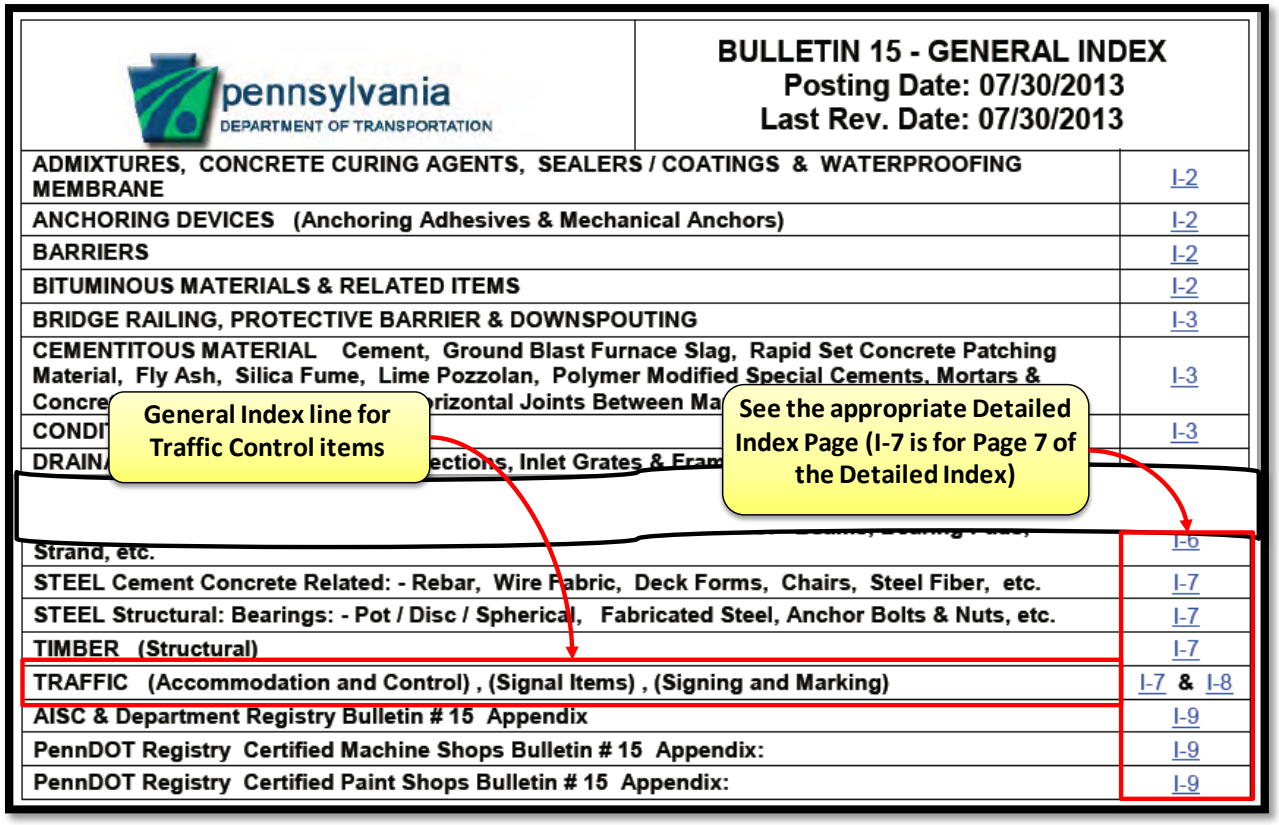
- ✓ Manufacturers
- ✓ Steel Epoxy Coaters or Galvanizers
- ✓ Wood Treaters
- ✓ Steel, Aluminum or Timber Fabricators
- ✓ Machine Shops
- ✓ Paint Shops
- ✓ Precast/Prestressed Concrete Producers
- ✓ Cement Plants or Terminals
- ✓ Pozzolan Providers
- ✓ Bituminous Terminals or Refineries

Suppliers, distributors, or companies that outsource the manufacturing of their products, or private label products that are manufactured by other companies are typically not eligible to submit a Product Evaluation Application (for approval and listing in Bulletin 15) unless the outsourcing company performs all required quality control testing and verifications and assumes full responsibility for the performance of the product. Non-eligible companies may obtain products or material from any approved source listed in Bulletin 15, for resale to pre-qualified contractors.

4.2.2 Bulletin 15 Listings

Bulletin 15 listings are organized in the format of Publication 408, Specifications. A General Index (sample shown in **Exhibit 4-2**) is followed by a more Detailed Index of listings (sample shown in **Exhibit 4-3**). The Detailed Index provides the date of the last revision of each section.

Exhibit 4-2 Bulletin 15 – General Index Sample



pennsylvania DEPARTMENT OF TRANSPORTATION

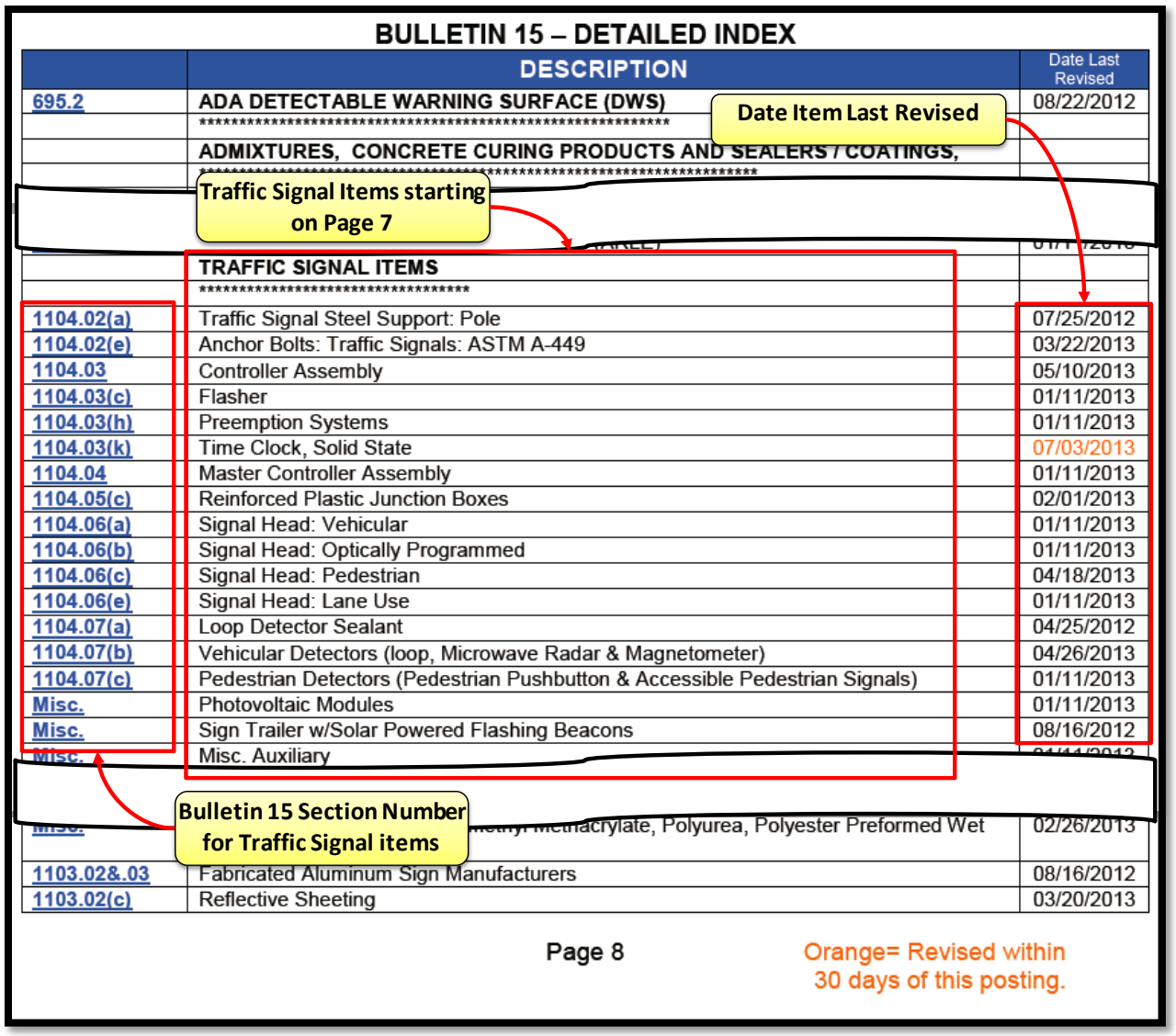
BULLETIN 15 - GENERAL INDEX
Posting Date: 07/30/2013
Last Rev. Date: 07/30/2013

ADMIXTURES, CONCRETE CURING AGENTS, SEALERS / COATINGS & WATERPROOFING MEMBRANE	I-2
ANCHORING DEVICES (Anchoring Adhesives & Mechanical Anchors)	I-2
BARRIERS	I-2
BITUMINOUS MATERIALS & RELATED ITEMS	I-2
BRIDGE RAILING, PROTECTIVE BARRIER & DOWNSPOUTING	I-3
CEMENTITOUS MATERIAL Cement, Ground Blast Furnace Slag, Rapid Set Concrete Patching Material, Fly Ash, Silica Fume, Lime Pozzolan, Polymer Modified Special Cements, Mortars & Concre…rizontal Joints Between Ma…	I-3
CONDI…	I-3
DRAIN…ections, Inlet Grates & Fram…	
Strand, etc.	I-6
STEEL Cement Concrete Related: - Rebar, Wire Fabric, Deck Forms, Chairs, Steel Fiber, etc.	I-7
STEEL Structural: Bearings: - Pot / Disc / Spherical, Fabricated Steel, Anchor Bolts & Nuts, etc.	I-7
TIMBER (Structural)	I-7
TRAFFIC (Accommodation and Control) , (Signal Items) , (Signing and Marking)	I-7 & I-8
AISC & Department Registry Bulletin # 15 Appendix	I-9
PennDOT Registry Certified Machine Shops Bulletin # 15 Appendix:	I-9
PennDOT Registry Certified Paint Shops Bulletin # 15 Appendix:	I-9

General Index line for Traffic Control items

See the appropriate Detailed Index Page (I-7 is for Page 7 of the Detailed Index)

Exhibit 4-3 Bulletin 15 – Detailed Index Sample



BULLETIN 15 – DETAILED INDEX

	DESCRIPTION	Date Last Revised
695.2	ADA DETECTABLE WARNING SURFACE (DWS)	08/22/2012
	**********	
	ADMIXTURES, CONCRETE CURING PRODUCTS AND SEALERS / COATINGS,	
	**********	
	TRAFFIC SIGNAL ITEMS	
	**********	
1104.02(a)	Traffic Signal Steel Support: Pole	07/25/2012
1104.02(e)	Anchor Bolts: Traffic Signals: ASTM A-449	03/22/2013
1104.03	Controller Assembly	05/10/2013
1104.03(c)	Flasher	01/11/2013
1104.03(h)	Preemption Systems	01/11/2013
1104.03(k)	Time Clock, Solid State	07/03/2013
1104.04	Master Controller Assembly	01/11/2013
1104.05(c)	Reinforced Plastic Junction Boxes	02/01/2013
1104.06(a)	Signal Head: Vehicular	01/11/2013
1104.06(b)	Signal Head: Optically Programmed	01/11/2013
1104.06(c)	Signal Head: Pedestrian	04/18/2013
1104.06(e)	Signal Head: Lane Use	01/11/2013
1104.07(a)	Loop Detector Sealant	04/25/2012
1104.07(b)	Vehicular Detectors (loop, Microwave Radar & Magnetometer)	04/26/2013
1104.07(c)	Pedestrian Detectors (Pedestrian Pushbutton & Accessible Pedestrian Signals)	01/11/2013
Misc.	Photovoltaic Modules	01/11/2013
Misc.	Sign Trailer w/Solar Powered Flashing Beacons	08/16/2012
Misc.	Misc. Auxiliary	
Misc.	...Methacrylate, Polyurea, Polyester Preformed Wet	02/26/2013
1103.02&.03	Fabricated Aluminum Sign Manufacturers	08/16/2012
1103.02(c)	Reflective Sheeting	03/20/2013

Date Item Last Revised

Traffic Signal Items starting on Page 7

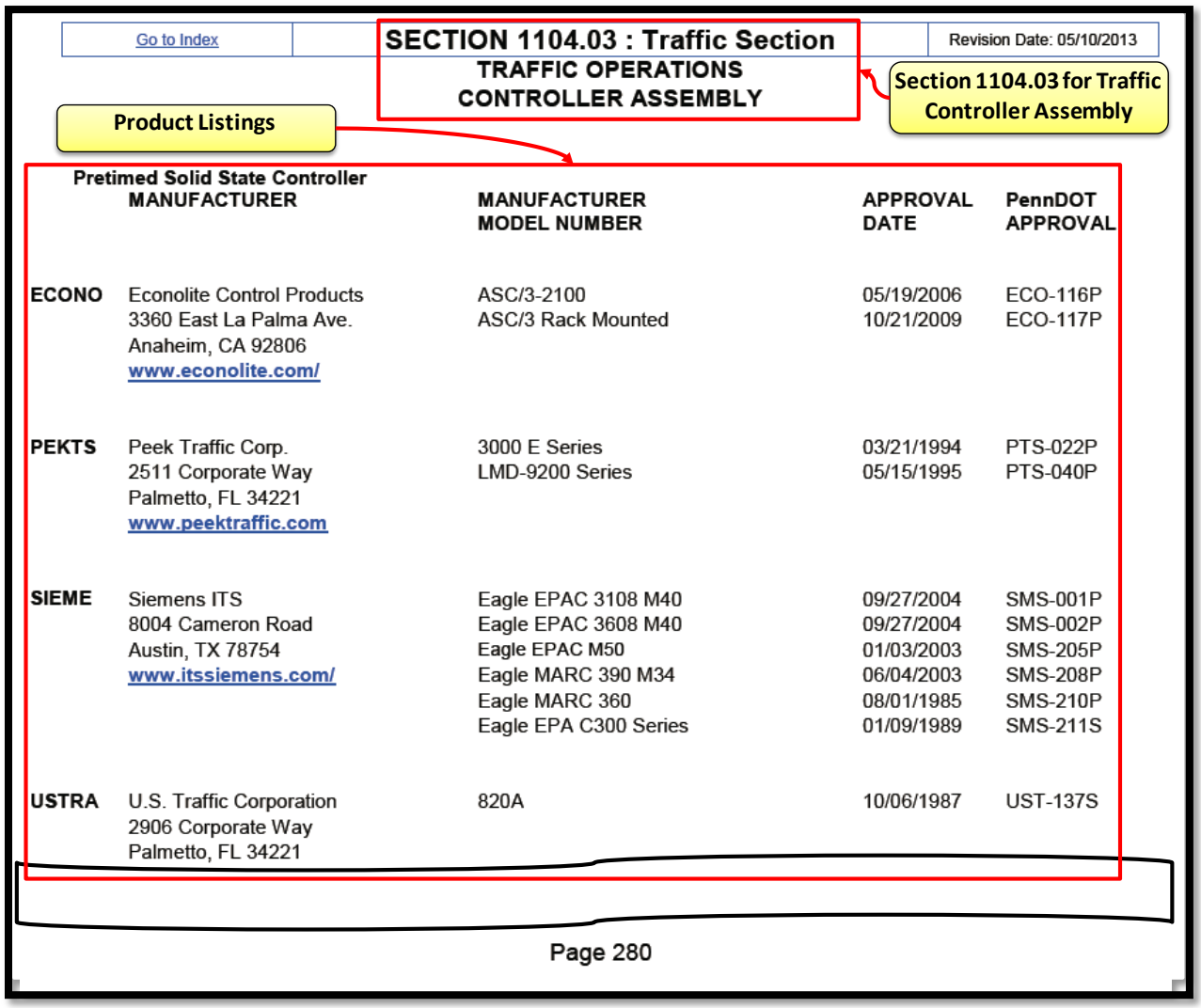
Bulletin 15 Section Number for Traffic Signal items

Page 8

Orange= Revised within 30 days of this posting.

A Bulletin 15 listing includes an assigned supplier code, the supplier name and address, the product name/type/use, and reference number. An example of Section 1104.03 for Traffic Operations Controller Assembly is shown in **Exhibit 4-4**. The reference number (Ref. No.) is the Product Evaluation/Product Evaluation Qualification (PE/PEQ) control number under which the item was tested and approved (the first two digits are the year of submission). The absence of a reference number (as shown in **Exhibit 4-4**) indicates that the item was approved prior to the implementation of the current number system. For precast and prestressed items, the reference number is the date of the approval letter from Department's Structural Materials Section. For traffic items, the Traffic Division "Approval Certificate" number is used.

Exhibit 4-4 Bulletin 15 – Section 1104.03 Sample



Go to Index

SECTION 1104.03 : Traffic Section
TRAFFIC OPERATIONS
CONTROLLER ASSEMBLY

Revision Date: 05/10/2013

Section 1104.03 for Traffic Controller Assembly

Product Listings

Pretimed Solid State Controller

	MANUFACTURER	MANUFACTURER MODEL NUMBER	APPROVAL DATE	PennDOT APPROVAL
ECONO	Econolite Control Products 3360 East La Palma Ave. Anaheim, CA 92806 www.econolite.com/	ASC/3-2100 ASC/3 Rack Mounted	05/19/2006 10/21/2009	ECO-116P ECO-117P
PEKTS	Peek Traffic Corp. 2511 Corporate Way Palmetto, FL 34221 www.peektraffic.com	3000 E Series LMD-9200 Series	03/21/1994 05/15/1995	PTS-022P PTS-040P
SIEME	Siemens ITS 8004 Cameron Road Austin, TX 78754 www.itssiemens.com/	Eagle EPAC 3108 M40 Eagle EPAC 3608 M40 Eagle EPAC M50 Eagle MARC 390 M34 Eagle MARC 360 Eagle EPA C300 Series	09/27/2004 09/27/2004 01/03/2003 06/04/2003 08/01/1985 01/09/1989	SMS-001P SMS-002P SMS-205P SMS-208P SMS-210P SMS-211S
USTRA	U.S. Traffic Corporation 2906 Corporate Way Palmetto, FL 34221	820A	10/06/1987	UST-137S

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Bulletin 15 listings will indicate if a supplier is on a reduced Level of Certification. Producers are assigned a Level of Certification, based on their ability to comply with the specification (Publication 408, §106.03(b)3).

Bulletin 15 listings will also indicate by notation if a product has received either a Provisional Approval or a Conditional Approval. These approval categories usually involve products that require further monitoring. The Department has the right to remove and provisionally approve or conditionally approve manufacturers and/or products from bulletin 15 immediately.

- ✓ Provisionally approved products are typically products approved under provisional specifications.
- ✓ Conditionally approved products are products approved under manufacturer's specifications. PennDOT may supplement or modify the manufacturer's specifications as needed using special provisions. (Note: If no Publication 408 specification section

applies to a conditionally approved product, it will be listed in the 'conditionally approved Items' section of Bulletin 15.)

- ✓ Prior to use, manufacturers must contact PennDOT each time a provisionally or conditionally approved product is to be used on a PennDOT project. Provisionally and conditionally approved products will be monitored for an appropriate period of time, based upon product type and risk. If the monitoring and evaluation of a provisionally or conditionally approved product is successful, the provisional or conditional approval notation in Bulletin 15 may be removed.

4.2.3 Bulletin 15 Removal Actions

A manufacturer and/or product(s) may be removed from Bulletin 15 for any of the following reasons:

- ✓ Any action or inaction that may affect the quality of the product, the integrity of the test results, or the implementation of the Quality Control Plan.
- ✓ Failure of the product to meet appropriate specifications.
- ✓ Failure to submit or adhere to a Quality Control Plan.
- ✓ Falsification of information provided on the Certificate of Compliance Form CS-4171, CS-4171C or CS-4171F.
- ✓ Failure to supply samples, test results, or other information requested by the Department.
- ✓ Failure to notify the Bulletin's Administrator at (717) 783-9673 within ten days of any change in company contact information (name, address, or phone number) or change in product information (name, formula, quality control plan, or manufacturing process).
- ✓ Commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements or receiving stolen property.
- ✓ Commission of fraud or a criminal offense or other improper conduct or knowledge or approval of, or acquiescence in these activities by an affiliate, officer, employee or other individual or entity associated with either obtaining, attempting to obtain or performing a public contract or subcontract. Acceptance of the benefits derived from the conduct will be deemed evidence of knowledge, approval or acquiescence.
- ✓ Violation of federal or state antitrust statutes.
- ✓ Violation of a state or federal law regulating campaign contributions.
- ✓ Violation of a state or federal environmental law.
- ✓ Violation of a state of federal law regulating hours of labor, minimum wage standards or prevailing wage standards: discrimination in wages or child labor violations.
- ✓ Violation of the Workers' Compensation Act (77 P. S. §§1-2626).
- ✓ Violation of a state or federal law prohibiting discrimination in employment.
- ✓ Suspension or debarment by the Commonwealth or an agency thereof or an agency of another state or by an agency or department of the federal government.

- ✓ Three or more occurrences of being declared ineligible for a contract.
- ✓ Unsatisfactory performance including failure to comply with the terms of a Commonwealth contract or subcontract including:
    - Willful failure to perform in accordance with the terms of one or more contracts, or a history of failure to perform, or of unsatisfactory performance of one or more contracts.
    - Failure to complete the work in the time frame specified in the contract.
    - Being declared in default on prior work or project.
    - Failure to submit documents, information or forms as required by contract.
    - Making false statements or failing to provide information or otherwise to cooperate with the contracting agency, the Office of State Inspector General or other Commonwealth authorities.
    - Discrimination in violation of laws or regulations in the conduct of business.
- ✓ Providing false or misleading information to the Office of State Inspector General, Office of the Budget, the Department of the Auditor General, the Office of Attorney General, the Treasury Department, the Board of Claims, or other tribunal or court, the Department, or a representative of an agency as part of any investigation, audit, program review, certification, contract bids or proposals, applications or claims for payment. This information includes:
    - Financial statements.
    - Nondiscrimination forms.
    - Affidavits or statements of compliance with prevailing wage statutes.
    - Product descriptive literature and documents submitted in connection with claims for payment made or litigation against Commonwealth agencies.
- ✓ Other acts or omissions indicating a lack of skill, ability, capacity, quality control, business integrity or business honesty.

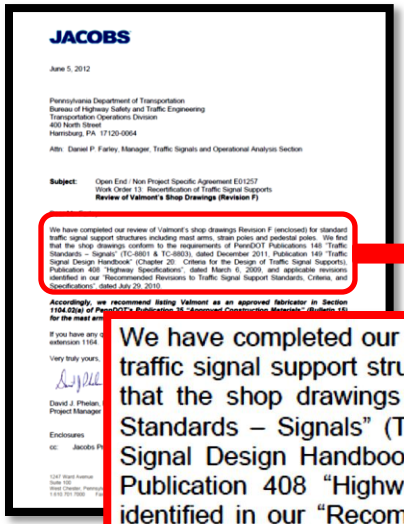
4.2.4 Department Shop Drawing Approval

Shop drawings are required for all traffic signal supports on each project. The Department has a pre-approval for standard traffic supports. The district or consultants only need to verify that loading meets contract requirements and matches pre-approved drawings. This creates a simplified review process. An example letter and shop drawing are shown in **Exhibit 4-5**. Approved shop drawings are stored on the Departments traffic signal portal.

Special designs do require full design, review and approval on a project specific basis. Some examples of special traffic signal support designs include:

- ✓ Mast arms greater than 60’
- ✓ Loading exceeding requirements specified in Publication 149
- ✓ Double mast arm structure at 90 degrees

Exhibit 4-5 Sample Letter for Approved Drawing



JACOBS

June 5, 2012

Pennsylvania Department of Transportation
Bureau of Highway Safety and Traffic Engineering
Transportation Operations Division
400 North Street
Harrisburg, PA 17120-0064

Attn: Daniel P. Farley, Manager, Traffic Signals and Operational Analysis Section

Subject: Open End / Non Project Specific Agreement E01257
Work Order 13: Recertification of Traffic Signal Supports
Review of Valmont's Shop Drawings (Revision F)

We have completed our review of Valmont's shop drawings Revision F (enclosed) for standard traffic signal support structures including mast arms, strain poles and pedestal poles. We find that the shop drawings conform to the requirements of PennDOT Publications 148 "Traffic Standards – Signals" (TC-8801 & TC-8803), dated December 2011, Publication 149 "Traffic Signal Design Handbook" (Chapter 20: Criteria for the Design of Traffic Signal Supports), Publication 408 "Highway Specifications", dated March 6, 2009, and applicable revisions identified in our "Recommended Revisions to Traffic Signal Support Standards, Criteria, and Specifications" dated July 29, 2010.

Accordingly, we recommend listing Valmont as an approved fabricator in Section 1104.02(a) of PennDOT's Publication 35 "Approved Construction Materials" (Bulletin 15) for the mast arm

If you have any q
extension 1164

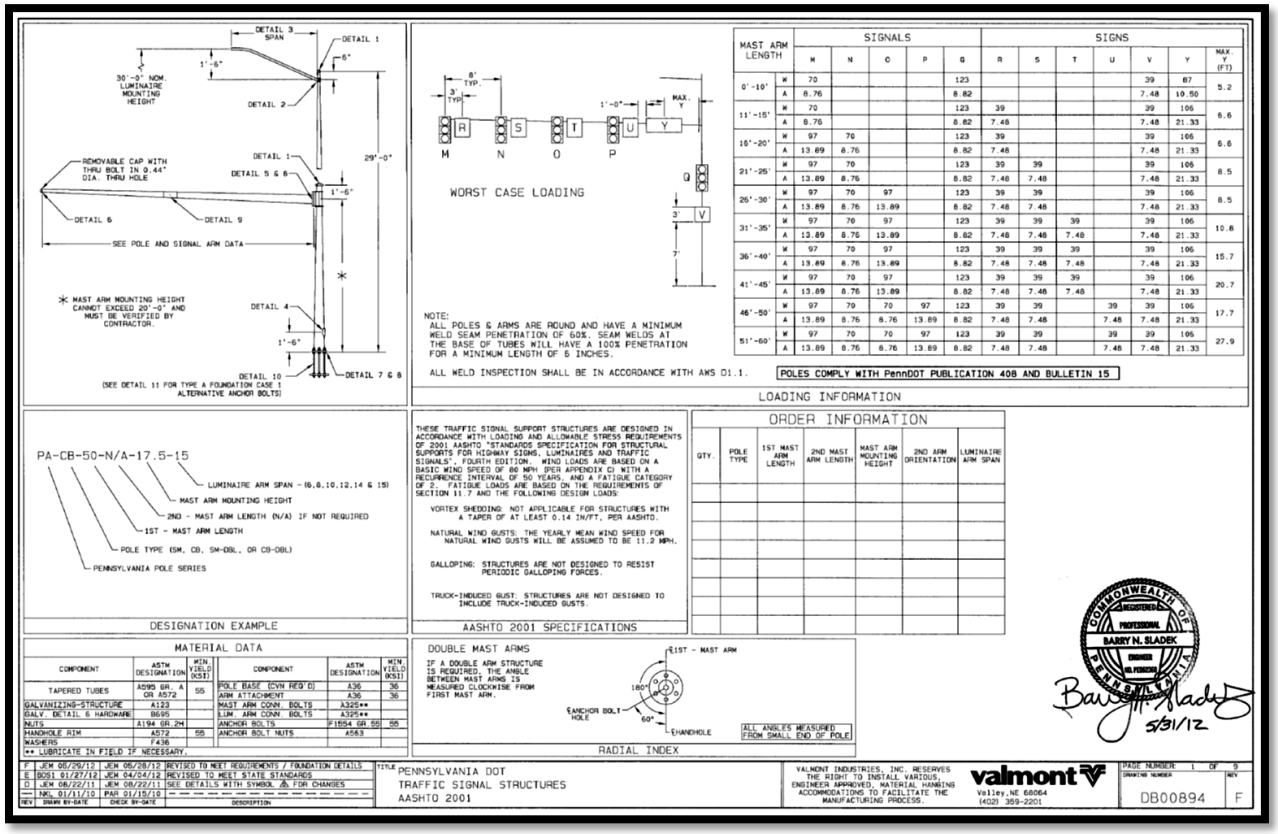
Very truly yours,

David J. Phelan
Project Manager

Enclosures
cc: Jacobs P

1247 Ward Avenue
Suite 100
West Chester, Pennsylvania
1 610 701 7500

We have completed our review of Valmont's shop drawings Revision F (enclosed) for standard traffic signal support structures including mast arms, strain poles and pedestal poles. We find that the shop drawings conform to the requirements of PennDOT Publications 148 "Traffic Standards – Signals" (TC-8801 & TC-8803), dated December 2011, Publication 149 "Traffic Signal Design Handbook" (Chapter 20: Criteria for the Design of Traffic Signal Supports), Publication 408 "Highway Specifications", dated March 6, 2009, and applicable revisions identified in our "Recommended Revisions to Traffic Signal Support Standards, Criteria, and Specifications", dated July 29, 2010.



4.3 Catalog Cut Sheets

A cut sheet is a general term for a few pages of specifications, instructions, dimensions, etc. that apply to traffic signal products, generally shipped with the product. They are called cut sheets because they are frequently pages which are "cut" from the company catalog.

Cut sheets are generally specific enough to convey any information that might be needed to install or use the product.

Product catalog cut sheets should include the following information:

- ✓ Manufacturer's make and model number for each piece of equipment
- ✓ Quantity of items to be used
- ✓ Catalog Cuts may or may not require an Engineer's seal. The Department requires an engineering seal for Structural Support submissions.
- ✓ Either the traffic signal unit or materials unit usually pre-approves the catalog cut sheets on either the CS-201 or directly on the cut sheets.

4.4 Proprietary Equipment Approvals

Note: Refer to Publication 51 on the use of proprietary items.

Occasionally, the Department receives requests from municipal officials to specify a particular brand of traffic signal equipment in the special provisions for a project. Although it is the policy of the Department and the Federal Highway Administration to use non-proprietary specifications on all projects, review requests of this type to determine if this equipment is essential for compatibility with existing signal equipment or if it is in the public interest to obtain major signal hardware from a particular manufacturer.

It is important to consider any proprietary specifications early in preliminary design to obtain any necessary approvals and to help the municipal officials understand all cost implications.

Therefore, if there is more than one non-proprietary product or material that will fulfill the requirements for an item of work or project, prepare the PS&E for the project to allow all such materials providing:

- ✓ All products are of satisfactory quality and are equally acceptable based on an engineering analysis.
- ✓ The anticipated prices for the related items of work are approximately the same.

4.5 Testing

The contractor is required to perform tests on various items during the construction of a traffic signal project. Documentation of some test results is required by the contractor, all other tests will have to be documented by the inspector. Following is a tabulation of required tests with references to the section of the specification requiring the test.

The tests listed in Exhibit 4-6 must be performed using equipment manufactured for the specified test. The equipment should contain the manufacturer's instructions on its use.

Exhibit 4-6 Traffic Signal Item Testing

Publication 408 Section	Test Performed
Sec. 1104	Controller Assembly Shop Test.
Sec. 1104	Traffic Signal Installation 30-Day Operating Test.
Sec. 952.3(a)	Malfunction Management Unit or Conflict Monitor Function Test.
Sec. 952.3(b)	Time Clock Evaluation.
Sec. 953.3(d)	30-Day Systems and Communications Test.
Sec. 954.3(j)	Traffic Signal Circuits Test for Short Circuits, Unspecified Grounds, and Resistance to Earth Ground.
Sec. 956.3(a)	Loop Detector Leakage Resistance, Series Resistance, and Inductance Testing.
Sec. 956.3(a)	Earth's Magnetic Flux Test and Magnetometer Detector Leakage and Series Resistance Test.
Sec. 956 3(a)	Magnetic Detector Leakage and Series Resistance Test.
Sec. 956.3(b)	Pedestrian Pushbuttons Evaluation and Pedestrian Phase Timing Test.
Sec. 953.3(k)	Traffic Signal Communications Test for Short Circuits, Unspecified Grounds, and Resistance to Ground.

4.5.1 Rotational Capacity Test

This method of test is in accordance with AASHTO M-164 (ASTM A-325). Per ASTM A-325 section 6.3.1, the rotational capacity test is defined as a test, "that is intended to evaluate the presence of a lubricant, the efficiency of the lubricant, and the compatibility of assemblies as represented by the components selected for testing."

PennDOT's Publication 19 – Field and Laboratory Testing Manual includes a variety of Pennsylvania Testing Methods (PTMs). The Rotational Capacity Test is included in Publication 19 as PTM 427.

4.5.2 High Strength Bolt Inspection Testing

This method of test is in accordance with AASHTO M-164 (ASTM A-325), and AASHTO M-253 (ASTM A-490). The High Strength Bolt Inspection Test is included in Publication 19 as PTM 429.

4.5.3 Bench Testing

Bench testing is "the critical evaluation of a new or repaired component, device, apparatus, etc., prior to installation to ensure that it is in perfect condition." For traffic signal projects, the following bench tests may be performed. Note that additional tests may be required for a specific project.

- ✓ The components will be bench tested for compatibility with all NEMA signal controller assemblies used by the Department. Each of the components will be verified for full NEMA functionality and full manufacturer's claimed optional functionality.
- ✓ Bus Interface Unit (BIU) components NEMA specified tolerances will be verified using a ATSI Bus Interface Unit (BIU) tester in accordance with manufacturer's operating procedures.
- ✓ MMU components NEMA specified tolerances will be verified using a ATSI Conflict Monitor / Malfunction Management Unit (MMU) tester in accordance with manufacturer's operating procedures.
- ✓ The TYPE I or II Controller will be verified for full NEMA functionality and full manufacturer's claimed optional functionality.
- ✓ The loop amplifier will be verified for full NEMA functionality and full manufacturer's claimed optional functionality. NEMA specified tolerances will be verified using a ATSI Card Rack Counting Loop Amplifier tester in accordance with manufacturer's operating procedures.
- ✓ The TS-2 Card Rack Counting Loop Amplifier will be verified for full NEMA TS-2 functionality and full manufacturer's claimed optional functionality. NEMA specified tolerances will be verified using a ATSI Card Rack Counting Loop Amplifier tester in accordance with manufacturer's operating procedures.
- ✓ The Field Master Controller will be verified for full NEMA functionality and full manufacturer's claimed optional functionality.

4.5.4 Field Testing

The field testing of the component will consist of installing the cabinet component in an actual traffic signal system for the specified testing period to monitor the following:

- ✓ Any failures for the component
- ✓ The relative ease of use for the field personnel
- ✓ Overall build quality and expected lifecycle of the cabinet component. This requirement shall be comparable with existing approved components.

4.6 Traffic Signal Specifications Sheet

PennDOT BOMO maintains a traffic signal specifications sheet for many commonly used traffic signal products. **Exhibit 4-7** shows a page from the PennDOT traffic signal portal, www.dot.state.pa.us/Portal%20Information/Traffic%20Signal%20Portal/catalogcut.htm.

Exhibit 4-7 Traffic Signal Specification Sheet

Traffic Signal Specifications Sheet

Note: The below items are to be used as a guide and a complete product review should be conducted based on the project requirements.

	Publication 408 Reference			Publication 148 Reference				
ITEM	Materials	Construction	Measurement and Payment	Standard Drawing	Central Office Specification	National Reference	PennDOT Approval # Required	Active Product Approval Listing PennDOT Publication 35 (Bulletin 15)
12-Inch LED Vehicle Arrow Traffic Signal Module	950.2	None	None	None	April 9, 2008; Specification for 12-Inch LED Vehicle Arrow Traffic Signal Modules	July 1, 2007; ITE Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement" and MUTCD 2009 Edition.	YES	1104.06(a)
Accessible Pedestrian Signal	950.2	None	None	TC-7803 and RC-67	None	MUTCD 2003 Edition	YES	1104.07
Acoustic Preemption system	950.2	None	None	None	None	MUTCD 2003 Edition	YES	1104.07
Adaptive Traffic Systems	None	None	None	None	May 10, 2010; Approval Requirements for Traffic Adaptive Systems	Highway Capacity Principles	NO	None
Cable Terminal/Harness Assembly	952.2, 954.2, 1104.03(f)	952.3	None	None	None	Per National Electric Code and State Electric Policy	NO	None
Cellular Communications System	None	None	None	None	None	None	None	None
Circuit Breaker	952.2, 954.2, 1104.03(g)1	952.3	None	None	None	Per National Electric Code and State Electric Policy	NO	None
Circular LED Vehicle Traffic Signal Module	950.2	None	None	None	April 9, 2008; Specification for Circular LED Vehicle Traffic Signal Modules	June 27, 2005; ITE Standard for ITE "Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement" and MUTCD 2009 Edition.	YES	1104.06(a)
Closed loop Signal System	953.2	953.3	None	None	None	None	None	None
Conduit	954.2, 1104.05(a)	954.3(b)	954.4(a)	TC-7804	None	National Electric Code	NO	None
Conflict Monitor	952.2, 954.2, 1104.01, 1104.03	952.3	952.4	None	None	MUTCD 2003 Edition	NO	None
Controller	950.2, 952.2, 954.2, 1104.01, 1104.03	952.3	952.4	None	None	MUTCD 2003 Edition	YES	1104.03

The traffic signal specifications sheet used in the manual is from September 19, 2013. It includes 77 different products. A handout of this version of the traffic signal products sheets is included at the end of this chapter for reference. This document is updated frequently, so only use the latest version found on the portal.

The sheet includes the following items:

- ✓ Item – The actual traffic signal product or material
- ✓ Publication 408 (Standard Specifications) reference for materials, construction, and measurement and payment
- ✓ Publication 148 standard drawing references
- ✓ Any Central Office specifications
- ✓ Information on any national references
- ✓ Indication as to whether PennDOT approval is required
- ✓ The active product approval listing in PennDOT Publication 35 (Bulletin 15) if it exists

Exhibit 4-8 is an example line item from the traffic signal specification sheet. This line item, Traffic Signal Support – Mast Arm, includes a reference for each column listed.

Exhibit 4-8 Example Item from Traffic Signal Specification Sheet

ITEM	Publication 408 Reference			Publication 148 Reference	Central Office Specification	National Reference	PennDOT Approval # Required	Active Product Approval Listing PennDOT Publication 35 (Bulletin 15)
	Materials	Construction	Measurement and Payment	Standard Drawing				
Traffic Signal Support – Mast Arm	951.2,1104.01, 1104.02	951.3	951.4	TC-8801	Publication 149, Chapter 20	AASHTO 2001 and MUTCD 2009 Edition	YES	1104.02

The following subsections expand on the information found for the example line item in Exhibit 4-8.

4.6.1 Item: Traffic Signal Support – Mast Arm

4.6.2 Publication 408, Materials: 951.2

951.2 MATERIAL— Sections 1104.01 and 1104.02 and as follows:

- Reinforcement Steel—Section 709.1
- Conduit—Section 1104.05(a)
- Class A Cement Concrete—Section 704
- Ground Rod—Section 1101.11(j)
- Nonshrink Mortar—Section 1001.2(e)
- Metal screening—Section 1101.02
- Premolded Expansion Joint Filler—Section 705.1

4.6.3 Publication 408, Materials: 1104.01

1104.01 GENERAL REQUIREMENTS—Comply with the requirements of associations, societies, codes, and regulations, as applicable, pertaining to the work of furnishing and installing operational traffic signals; including traffic signal supports, controller assemblies, traffic signal systems and communications, electrical distribution, traffic signal indications, and detectors.

Words and phrases specific to traffic signals that are not defined in these specifications or in the regulations, are to be defined as in NEMA TS 1, NEMA TS 2, Type 170-ATC, or Type 2070-ATC industry standards.

(a) Traffic Signals Materials Acceptance. Before the submission of a bid proposal, verify that Bulletin 15 approved products issued by the Department, for traffic signal equipment, as provided in 67 PA Code, Chapter 212.

At least 3 weeks before their installation, submit to the Representative, for review and acceptance, a tabulation of all project traffic signal materials. Include the type of material, manufacturer's name, model number, and the Department's Certificate of Approval number for each item to be supplied. Refer to Publication 46 to obtain the listing of traffic signal items that require Bulletin 15 approval. Provide catalog cuts for further clarification of the material, when requested.

(b) Structural Material. Fabricate traffic signal structural material according to Section 1105 (steel members only), AWS, and the AASHTO Specifications; except, applying water to the base metal during plasma arc cutting is permitted. Bulletin 15 listing and shop inspection is required. Fabricators provide an AWS certified welding inspector (CWI) for welded steel or aluminum pole products as specified in Section 1105.01(g)3. Bulletin 15, shop inspection, and Section 1105 do not apply to painting of aluminum poles and for the following non-welded items: cast aluminum poles, cast steel poles, and cast iron poles.

The Charpy V-Notch toughness test is required for load carrying tension members greater than 1/2-inch in thickness, as required for Zone 2, non-fracture critical criteria, of the applicable AASHTO specifications.

Provide steel poles that either round or multi-sided with a minimum of eight sides.

Provide testing and test methods according to AWS D1.1 (Steel) or AWS D1.2 (Aluminum) and as determined by the LTS.

Provide non-destructive testing on 100% of full penetration groove welds and a random 25% of partial penetration groove welds of longitudinal seams on steel poles and arms. When inspecting full penetration seam welds, use radiographic test methods on material less than 5/16-inch in thickness, and use radiographic or ultrasonic test methods on material 5/16-inch and greater in thickness. Use magnetic particle inspection on partial penetration seam welds.

Provide non-destructive testing by ultrasonic test methods on random 25% of all pole to base plate and arm to arm plate full penetration groove welds. For tube material less than 5/16-inch in thickness, have the fabricator submit a detailed ultrasonic testing procedure, including acceptance criteria, to the LTS for review and approval before testing.

For all other welds on steel traffic poles, perform magnetic particle inspection on a minimum of 25% of the length of each weld. Provide inspection for the full length of the weld when less than 6 inches in length.

For aluminum traffic pole structures, perform fabrication and non-destructive testing in accordance with Section 1101.01.

Where less than 100% of the weld is non-destructively tested, and a rejectable defect is found, test 100% of the length of the weld.

Where applicable, the Department's plant inspector will select portions of welds to be tested.

Perform and evaluate all non-destructive testing according to cyclically loaded non-tubular tension criteria.

(c) Certification. As specified in Section 106.03(b)3. Certify from the manufacturer, that all signal supports satisfy the Department's criteria and are adequate to support the loads indicated on the approved plans. Include on the certification the signature and seal of a Professional Engineer registered in the State. Certify the structural adequacy of all sign and signal brackets as well as all other mounting hardware.

(d) Traffic Signal Controllers. Provide switches, controls, and indicators that are operable without the use of tools. Clearly and permanently identify the switches, controls, and indicators.

Furnish three copies of warranties, guarantees, instruction manuals, wiring diagrams, and parts' lists with each different type material. Also, provide in the controller assembly cabinet one instruction manual for each controller unit, time clock, and coordination unit.

Upon completion of a controller assembly, conduct a physical and functional shop test of the assembly's continuous, satisfactory operation, for not less than 7 calendar days, in accordance with industry standards. Provide 300 W loads for signal circuit and simulated inputs for detectors, and interconnection. Certify that the equipment operates as indicated. Demonstrate and provide written documentation that the conflict monitor or malfunction management unit will cause transfer of the signals to flashing operation upon sensing all possible conflicting signal indications.

Label the load switch sockets and cable connectors for detector amplifiers, in the controller assembly, according to function.

All equipment which requires a separate device to set, adjust, or read the timing intervals, furnish plans or programs with one of these devices for each ten units or fraction thereof.

(e) Wiring Diagrams and Timing Plans. Provide three copies of the cabinet wiring diagram, traffic signal equipment wiring diagram, approved plans, and manufacturer's timing plan for each controller assembly, in accordance with the approved signal construction drawings. Place a clear protective envelope in the controller assembly cabinet that contains one copy of the manufacturer's instruction manual for each controller unit, time clock, coordination unit, software programming manuals, time setting charts, wiring diagrams, and parts list. Upon completion of the 30-day test, if there were any changes that would affect a change to these documents, then provide three new copies of each.

(f) Shop Testing. Submit results from shop tests to the Representative as specified in Section 952 and most recent publication for the applicable controller type as follows:

- NEMA TS1 Standard "Traffic Control Systems" (for existing traffic control equipment)
- NEMA TS2 Standard "Traffic Controller Assemblies With NTCIP Requirements"
- Type 170 Industry Standard
- Type 2070 Industry Standard

(g) Standard Construction Practices. As shown in Sections 910.3(a) and 1105, the Standard Drawings, and as follows:

Existing traffic signals are to remain in operation, as is, until the new traffic signal equipment and devices are in place and operable unless an approved plans indicates otherwise. If it becomes necessary to turn off the existing system of signalization, obtain the District Traffic Engineer's approval, municipal concurrence, and provide flaggers or other approved means to direct traffic within the intersection during periods when the traffic signals are not operating. Place temporary poles to adequately support existing traffic signals, as indicated or directed. Provide certification to the Department that such poles have sufficient strength to support the traffic signals.

Make revisions to the existing system of signalization, as indicated or directed.

Before any excavation for placement of traffic signal or sign support poles, mark proposed locations in the field. Field review pole locations with the Representative and adjust pole locations as necessary.

Remove all existing traffic signal supports, including those with traffic signals, flashing warning devices, and lane control signs and signal equipment, unless otherwise indicated.

Maintain existing controller assemblies, as a unit. Store material on the project site. Provide a listing of the equipment for the municipal owner and make arrangements to deliver equipment to the municipal storage area. Do not damage items during removal and storage.

Abandon underground conduit, conductors, and detectors not interfering with new construction. Remove foundations and junction boxes that are designated to be abandoned and are located in an "off traveled roadway" area, to 1 foot below final grade and dispose of removed materials. Fill, compact, and landscape the resulting hole, including topsoil if necessary by the particular planting.

Repair damage to galvanized finishes.

Restore areas damaged by construction.

If any vegetation is blocking the visibility of signs or traffic signals, in the opinion of the Representative, generate and submit a list of items to the Representative. Obtain approval to remove or relocate any of the items.

If not notified by the Representative, notify the Representative as soon as it is recognized that a utility facility is causing, or will cause, an obstruction to visibility.

Before the initial turn-on, verify for the Representative that all traffic signals are working properly. Make the initial turn-on to flashing mode and full operation in the presence of the Representative between the hours of 9 AM and 2 PM, Tuesday through Thursday except holidays. Under special circumstances involving safety of motoring public, the Representative may grant exceptions to this rule. Give the Representative a minimum 7 calendar day notice before the initial turn-on. For locations presently unsignalized, flash signals for a period of 3 to 7 days.

Upon completion of a controller assembly, conduct a physical and functional shop test of the assembly's continuous, satisfactory operation, for not less than 7 calendar days, in accordance with industry standards. Provide 300 W loads for signal circuit and simulated inputs for detectors, and interconnection. Certify that the equipment operates as indicated. Demonstrate and provide written documentation that the conflict monitor or malfunction management unit will cause transfer of the signals to flashing operation upon sensing all possible conflicting signal indications.

Label the load switch sockets and cable connectors for detector amplifiers, in the controller assembly, according to function.

All equipment which requires a separate device to set, adjust, or read the timing intervals, furnish plans or programs with one of these devices for each ten units or fraction thereof.

(e) Wiring Diagrams and Timing Plans. Provide three copies of the cabinet wiring diagram, traffic signal equipment wiring diagram, approved plans, and manufacturer's timing plan for each controller assembly, in accordance with the approved signal construction drawings. Place a clear protective envelope in the controller assembly cabinet that contains one copy of the manufacturer's instruction manual for each controller unit, time clock, coordination unit, software programming manuals, time setting charts, wiring diagrams, and parts list. Upon completion of the 30-day test, if there were any changes that would affect a change to these documents, then provide three new copies of each.

(f) Shop Testing. Submit results from shop tests to the Representative as specified in Section 952 and most recent publication for the applicable controller type as follows:

- NEMA TS1 Standard "Traffic Control Systems" (for existing traffic control equipment)
- NEMA TS2 Standard "Traffic Controller Assemblies With NTCIP Requirements"
- Type 170 Industry Standard
- Type 2070 Industry Standard

(g) Standard Construction Practices. As shown in Sections 910.3(a) and 1105, the Standard Drawings, and as follows:

Existing traffic signals are to remain in operation, as is, until the new traffic signal equipment and devices are in place and operable unless an approved plans indicates otherwise. If it becomes necessary to turn off the existing system of signalization, obtain the District Traffic Engineer's approval, municipal concurrence, and provide flaggers or other approved means to direct traffic within the intersection during periods when the traffic signals are not operating. Place temporary poles to adequately support existing traffic signals, as indicated or directed. Provide certification to the Department that such poles have sufficient strength to support the traffic signals.

Make revisions to the existing system of signalization, as indicated or directed.

Before any excavation for placement of traffic signal or sign support poles, mark proposed locations in the field. Field review pole locations with the Representative and adjust pole locations as necessary.

Remove all existing traffic signal supports, including those with traffic signals, flashing warning devices, and lane control signs and signal equipment, unless otherwise indicated.

Maintain existing controller assemblies, as a unit. Store material on the project site. Provide a listing of the equipment for the municipal owner and make arrangements to deliver equipment to the municipal storage area. Do not damage items during removal and storage.

Abandon underground conduit, conductors, and detectors not interfering with new construction. Remove foundations and junction boxes that are designated to be abandoned and are located in an "off traveled roadway" area, to 1 foot below final grade and dispose of removed materials. Fill, compact, and landscape the resulting hole, including topsoil if necessary by the particular planting.

Repair damage to galvanized finishes.

Restore areas damaged by construction.

If any vegetation is blocking the visibility of signs or traffic signals, in the opinion of the Representative, generate and submit a list of items to the Representative. Obtain approval to remove or relocate any of the items.

If not notified by the Representative, notify the Representative as soon as it is recognized that a utility facility is causing, or will cause, an obstruction to visibility.

Before the initial turn-on, verify for the Representative that all traffic signals are working properly. Make the initial turn-on to flashing mode and full operation in the presence of the Representative between the hours of 9 AM and 2 PM, Tuesday through Thursday except holidays. Under special circumstances involving safety of motoring public, the Representative may grant exceptions to this rule. Give the Representative a minimum 7 calendar day notice before the initial turn-on. For locations presently unsignalized, flash signals for a period of 3 to 7 days.

1. 30-Day Testing. After the traffic signal installation becomes operational, conduct a continuous, 24 hour operating test for not less than 30 consecutive calendar days. Correct failures during the test period by repairing or replacing malfunctioning parts or equipment or faulty work regardless of the cause in less than 24 hours as directed. After correcting failures caused by defective equipment, material, or faulty work, re-conduct the 30-day test.

During the 30-day test period, change, adjust, or reinstall controller and/or master controller settings as directed at any time. Adjust or revise initial signal timing parameters, as directed, to optimize signal operation due to actual traffic flows and field conditions. During this time period, power and communication costs associated with maintaining the operation of the traffic signal will be the responsibility of municipality or other party that currently (or will ultimately) assume ownership or maintenance of the installation.

In addition to the provisions of Sections 105.10 and 107.10, those Department, Federal, and municipal personnel and agencies, as well as public and private interests, that are involved with the signal installation, have jurisdictional control over the installation or adjacent facilities, or will ultimately assume ownership or maintenance of the installation, will at the discretion of the Department, be allowed to observe signal turn-on, installation of initial timing parameters and any subsequent adjustment, and inspection before completion of 30-day test.

2. Equipment Guarantee. Guarantee the in service operation of mechanical and electrical equipment, related components, and the controller assembly for a period of 180 days from the date of completion of the specified 30 day field test. During this period:

- Maintain equipment in the controller cabinet. Use additional locks, as necessary, to prevent entry by others.
- Repair faulty work, repair or replace defective materials or equipment and correct malfunctions in the controller cabinet within 48 hours after starting repairs.
- Start repairs no later than the working day following notification of failures or malfunctions.
- Guarantee repairs or replacements for the balance of the 180-day guarantee period, or 30 days, whichever is the longer period.
- Repair or replacement work not performed within the guarantee period, or any extension period, will be considered latent defects as specified in Section 107.16(b).

Provide the Representative with the name and telephone number of the person to be notified in the event of failures or malfunctions during the guarantee period.

Issuance of an acceptance certificate or final settlement of the Contract does not in any respect relieve the Contractor of responsibility for the in-service guarantee period described in these Specifications.

4.6.4 Publication 408, Materials: 1104.02

1104.02 TRAFFIC SIGNAL SUPPORTS—

(a) General.

1. Design and Acceptance. Design in accordance with Publication 149. Submit shop drawings in accordance with Publication 149, including calculations for all special structures, for review and acceptance.

2. Supports. Fabricate shafts and arms in any of the following shapes and styles:

Round Tapered.

- One longitudinal seam, continuously welded, and ground or rolled flush.
- Transverse butt welds are not acceptable.
- Uniform wall thickness.
- Uniform taper, 0.14 inch maximum and 0.07 inch minimum per foot of length.

Round Stepped.

- Round pipe sections, each with not more than one longitudinal seam continuously welded and ground or rolled flush. Join sections by a hot-swaged shrink fit continuously seal-welded to prevent entrance of water.
- Uniform wall thickness for each section.
- Maximum change in diameter between stepped sections not to exceed 2 1/8 inches.

Multi-Sided Tapered.

- Maximum of two longitudinal seams, continuously welded, and ground or rolled to a maximum bead height of 1/8 inch.
- Transverse butt welds are not acceptable.
- Uniform wall thickness.
- Uniform taper, 0.14 inch maximum and 0.07 inch minimum per foot of length.
- Minimum of eight sides.

Round Untapered.

- Maximum of one longitudinal seam, continuously welded, and ground or rolled flush.
- Uniform wall thickness and diameter.
- Transverse butt welds are not acceptable

3. Cable Support. Weld a cable support to the inside top of the shaft.

4. Grounding. Weld a UL-Listed grounding lug, capable of accommodating a No. 6 AWG stranded copper cable, to the inside of the shaft adjacent to the handhole.

5. Handholes. Provide a handhole in the shaft of the poles, as shown on the Standard Drawings. Reinforce the area to develop the minimum guaranteed yield strength of the shaft. Furnish a cover and keeper chain.

6. Wire Inlets. Provide a wire inlet at each signal head or at each electrically operated sign location. Weatherproof each inlet with an insulated grommet.

Provide a deburred hole, 2 1/2-inch minimum diameter, in the flange plate and shaft, which serves as a wire entrance into the arm from inside the shaft.

Provide Type LB access fittings from Type II mounted controller cabinet into pole shaft and in pole shafts for pedestrian pushbuttons.

7. Anchor Bases.

- Fabricate the base clean, smooth, and of the dimensions necessary for adequate pole mounting and structural support.
- Provide holes for anchor bolts.
- Fabricate the base to telescope over the shaft and be secured in place by welding.

8. Galvanizing. Section 1105.02(s) and as follows:

Galvanize steel shafts and arms, including those manufactured of high strength and corrosion resistant steels, according to ASTM A 123 (AASHTO M 111). Galvanize accessories and hardware according to ASTM A 153 (AASHTO M 232).

(b) Overhead Supports. As shown on the Standard Drawings and as follows:

- Shaft and Arms—AASHTO M270/ASTM A709, Grade 36 or Grade 50, ASTM A36, ASTM A 53, ASTM A 572 Grade 50, ASTM A 501 and A 595.
- Luminaire Mounting Arms—Section 1101.03
- Anchor (Base) Plates, Flange (Arm and Column Connection) Plates, and Gusset Plates,—AASHTO

M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM A 572 Grade 50.

- Miscellaneous Shapes, plates and bars- AASHTO M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM, ASTM A 572 Grade 50 and ASTM A992.
- Flange Plate Assembly Bolts, Nuts and Washers— ASTM A325, ASTM 563 and ASTM F436. Mechanically galvanize in accordance with ASTM B695. Furnish bolts, nuts and washers for testing purposes and test as specified in Section 1050.3(c) 7.b.
- Shaft and Arm Caps—Galvanized steel (C-coat) cast iron or cast aluminum.
- Handhole CHandhole Cover Plates – AASHTO M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM, ASTM A 572 Grade 50 and ASTM A 1011
- Pipe Caps – AASHTO M 270 (ASTM A 709), Grade 36. ASTM A 36, ASTM, ASTM A 572, ASTM A 1011 or ASTM B 26
- Arm dampening – Harmonic dampening device, when provided.

(c) Pedestal Supports. As shown on the Standard Drawings and as follows:

1. Aluminum.

- Support—One length, 4 1/2-inch minimum outside diameter aluminum pipe, Schedule 40, ASTM B 210, or B 221, Alloy 6063-T6.
- Bases—Cast aluminum, ASTM B 26, or B 108, Alloy 356-T6; aluminum plate, ASTM B 209, Alloy 6061-T6.
- Pole Tops—Aluminum

2. Steel.

- Support—One length, 4 1/2-inch minimum outside diameter steel pipe, Schedule 40, ASTM A 53, Type F.
- Base—Steel casting, ASTM A 27, Grade 65-35; gray iron casting, ASTM A 126, Class 26; steel plate, AASHTO M 270 (ASTM A 709), Grade 36.

(d) Pedestrian Stub Poles. As specified in Section 1104.02(c) except having a fixed length of 60 inches and a rounded top cap to minimize injuries.

(e) Anchor Bolts. As shown on the Standard Drawings and as follows:

- Anchor Bolts—ASTM A 449 or F 1554.
- Hex Nuts—ASTM A 563M/A 563
- Washers—ASTM F 436

Galvanize the top 8 inches of bolts and all associated hardware as specified in Section 1105.02(s) (ASTM A 153), or by another acceptable method conforming to the coating thickness, adherence, and quality requirements of ASTM A 153. Furnish template prints for setting anchor bolts with each support.

(f) Wood Support Poles. When used for temporary signal installations, certify sawn material, both rough and dressed by the mill as to grade and mark in accordance with the grading rules and basic provisions of the American Lumber Standards (PS-20-70) by a lumber grading or inspection bureau or agency. If dressed, the grade mark shall be applied after dressing.

(g) Span Wire. ASTM A 475, Class A, Siemens-Martin, or ASTM B 416.

(h) Tether Wire. ASTM A 475, Class A, Siemens-Martin, or ASTM B 416.

(i) Lashing. As shown on the Standard Drawings for attaching cable to span wire.

4.6.5 Publication 408, Construction: 951.3

951.3 CONSTRUCTION—Section 950.3, as shown on the Standard Drawings, and as follows:

(a) Excavation. Before forming and placing concrete, each foundation excavation will be inspected for the actual soil conditions encountered. Do not proceed with the work until the excavation is accepted. If necessary, revise the foundation design based on the soil conditions encountered. Before submitting the revised design for approval, obtain the signature and seal of a Professional Engineer licensed in the State of Pennsylvania. Foundation locations may be changed to avoid underground obstructions, with written permission of the Representative.

(b) Foundations. Install reinforcement steel, anchor bolts, conduit sweeps, and ground rods with ground wire clamps. Orient the anchor bolt template to obtain the proper angle of the mast arm. Place concrete as specified in the applicable parts of Section 1001.3.

Backfill around the foundation in 150 mm (6-inch) layers with selected on-site material, then compact mechanically to the density of the undisturbed earth. Dispose of excess or unsuitable material. Place 12.7 mm (1/2-inch) premolded, expansion joint filler between the foundation and existing concrete sidewalks and pavements.

After placing concrete, do not install supports for a minimum of 72 hours.

(c) Traffic Signal Supports. Install supports, of the type indicated, on the foundation. Use leveling nuts on the anchor bolts to adjust the support shaft rake to provide a vertical set when the load is added.

Connect the ground wire to the grounding lug.

Install span and tether wires on strain poles. Allow enough span wire and tether wire length to fasten wire and for sag adjustment. After installing signal cable, signal heads, and signs, adjust sag of the span wire.

Check for vertical alignment of the shaft and for alignment of the mast arm after signals, brackets, signs, luminaires, and signal cable are in place. Adjust to the correct alignment.

Tighten anchor nuts, as specified in Section 1105.03.

Place nonshrink mortar. Provide the drain hole in the mortar. Finish mortar vertically at the outside edge of the base plate.

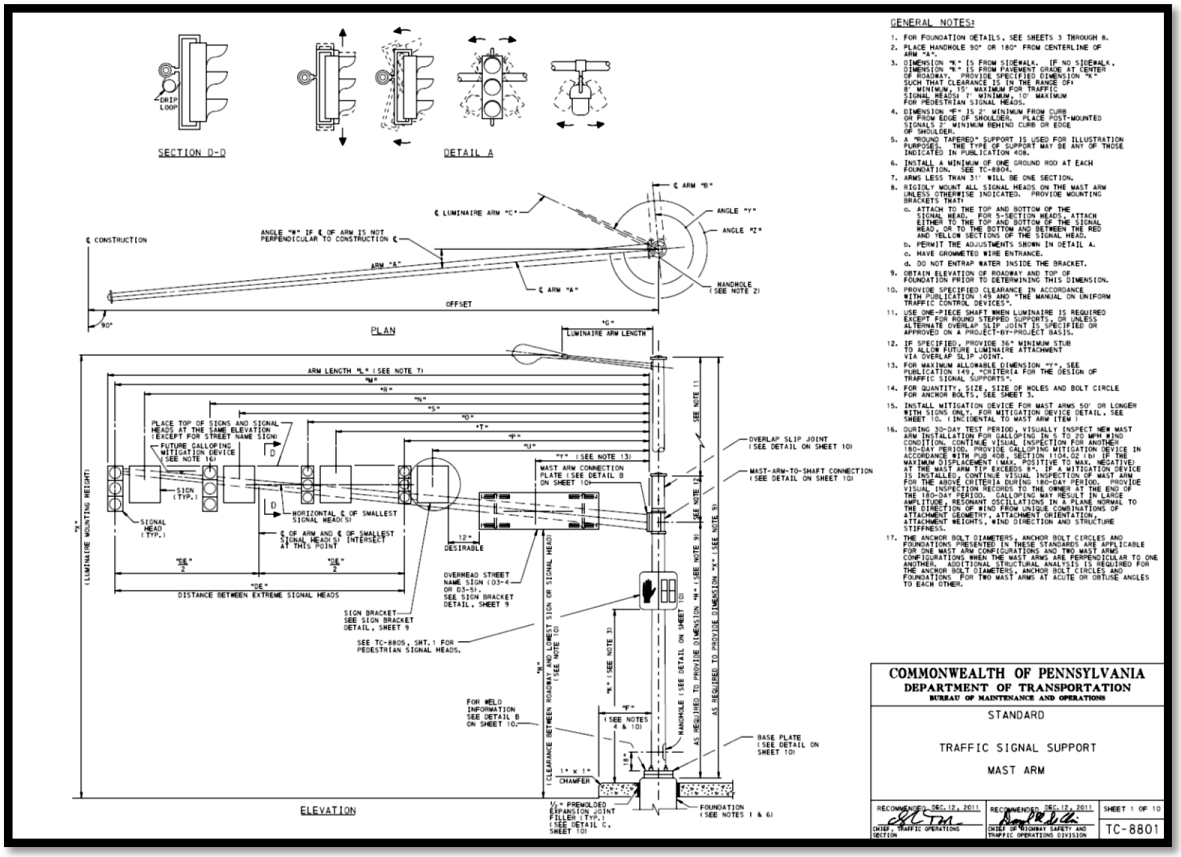
4.6.6 Publication 408, Measurement and Payment: 951.4

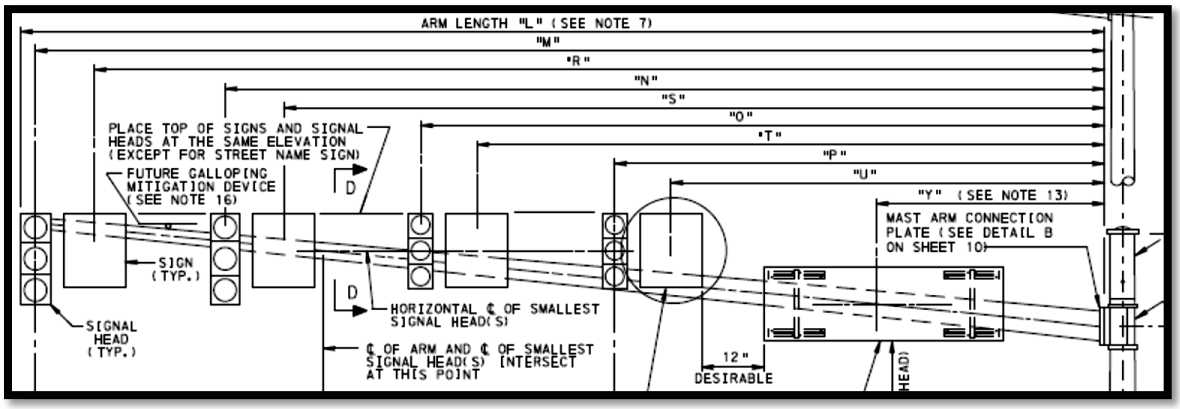
951.4 MEASUREMENT AND PAYMENT—Each and as specified in Section 950.4

950.4 MEASUREMENT AND PAYMENT—The removal and storage of existing traffic signal material, the restoration of areas damaged by construction, and testing are incidental to the work specified in Sections 951 through 957.

4.6.7 Publication 148, Standard Drawing: TC-8801

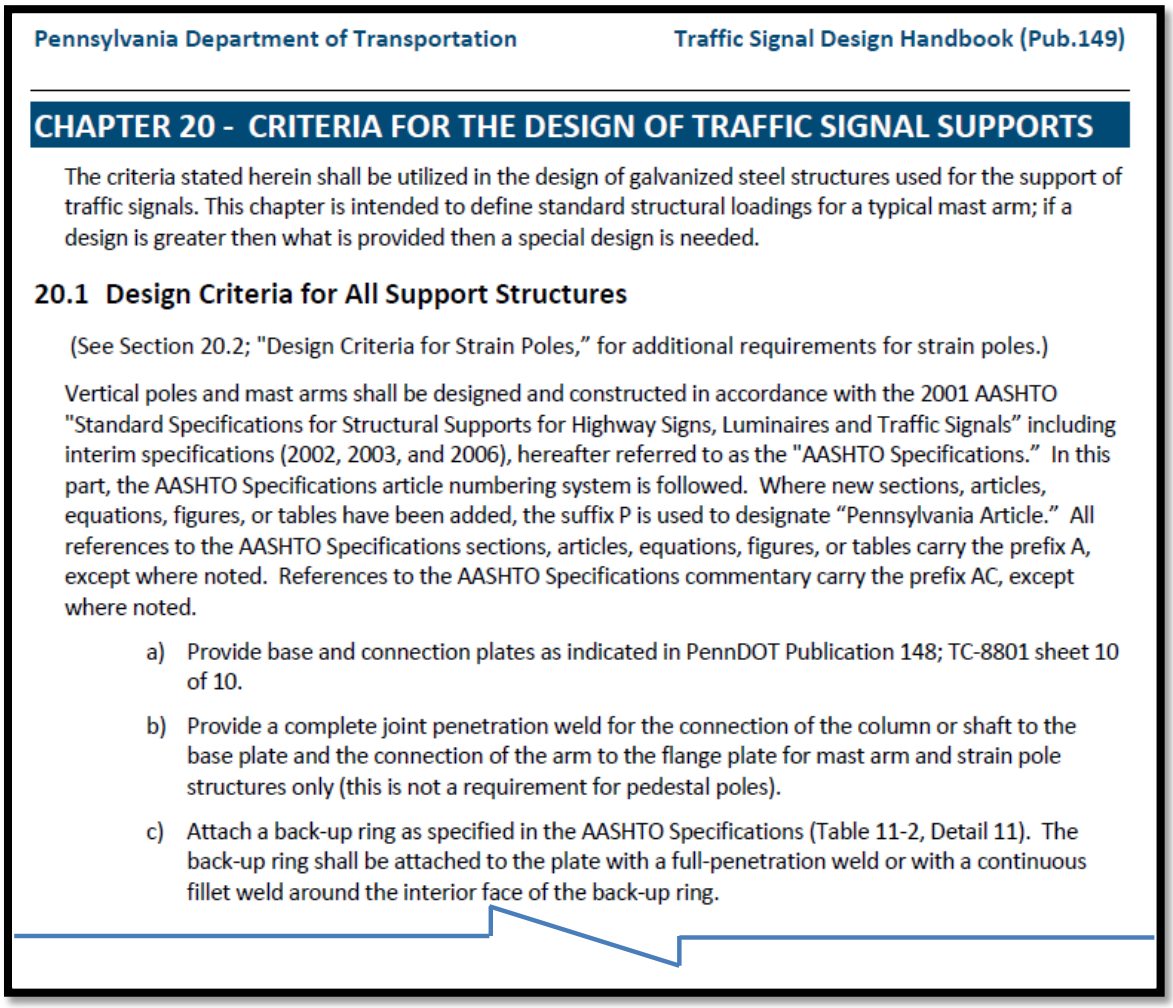
Sheet 1 of 10 only - refer to Publication 148 for additional information.





4.6.8 Central Office Specification: Publication 149, Chapter 20

Shown is a portion of page 20-1 of Publication 149. Additional pages/information can be found in the publication.



Pennsylvania Department of Transportation — Traffic Signal Design Handbook (Pub.149)

CHAPTER 20 - CRITERIA FOR THE DESIGN OF TRAFFIC SIGNAL SUPPORTS

The criteria stated herein shall be utilized in the design of galvanized steel structures used for the support of traffic signals. This chapter is intended to define standard structural loadings for a typical mast arm; if a design is greater then what is provided then a special design is needed.

20.1 Design Criteria for All Support Structures

(See Section 20.2; "Design Criteria for Strain Poles," for additional requirements for strain poles.)

Vertical poles and mast arms shall be designed and constructed in accordance with the 2001 AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" including interim specifications (2002, 2003, and 2006), hereafter referred to as the "AASHTO Specifications." In this part, the AASHTO Specifications article numbering system is followed. Where new sections, articles, equations, figures, or tables have been added, the suffix P is used to designate "Pennsylvania Article." All references to the AASHTO Specifications sections, articles, equations, figures, or tables carry the prefix A, except where noted. References to the AASHTO Specifications commentary carry the prefix AC, except where noted.

a) Provide base and connection plates as indicated in PennDOT Publication 148; TC-8801 sheet 10 of 10.

b) Provide a complete joint penetration weld for the connection of the column or shaft to the base plate and the connection of the arm to the flange plate for mast arm and strain pole structures only (this is not a requirement for pedestal poles).

c) Attach a back-up ring as specified in the AASHTO Specifications (Table 11-2, Detail 11). The back-up ring shall be attached to the plate with a full-penetration weld or with a continuous fillet weld around the interior face of the back-up ring.

4.6.9 National Reference: AASHTO 2001 and MUTCD 2009 Edition

Refer to the referenced documents for additional information.

4.6.10 PennDOT Approval # Required: YES

A PennDOT approval number is required for this item, Traffic Signal Support – Mast Arm. For traffic signal products in Publication 35 (Bulletin 15), the traffic division "Approval Certificate" number is used.

4.6.11 Active Product Approval Listing PennDOT Publication 35 (Bulletin 15): 1104.02

Go to Index	SECTION 1104.02	Revision Date: 07/25/2012

TRAFFIC SIGNAL SUPPORTS

	Pole Fabricators:	❶ **Steel**
SABIN	Sabre Ind. Tubular Str. - PA 700 Second Street Ellwood City, PA 16117 Formerly: Jet Industries (**JETIN**)	❶
UNIMC	Union Metal Corp. 1432 Maple Avenue, N.E. Canton, OH 44705	❶
VALM1	Valmont Industries, Inc. P.O. Box 358 Valley, NE 68064	❶
VALM2	Valmont Industries, Inc. 58027 Charlotte Avenue Elkhart, IN 46517	❶
VALM5	Valmont Industries, Inc. 2551 Valmont Drive Brenham, TX 77833	❶

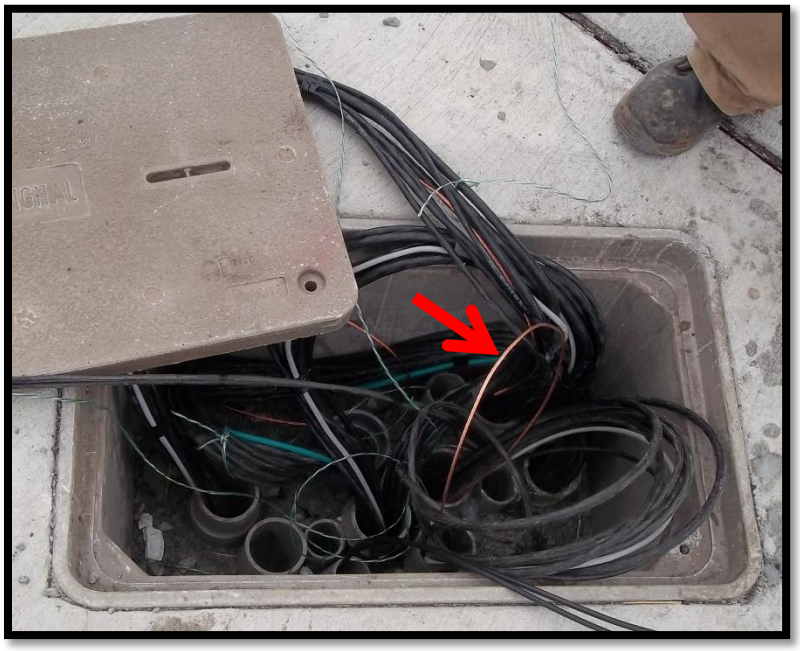
4.7 Common Electrical Materials

The following sections describe a variety of the commonly used electrical materials used on traffic signal projects. The list is not all-inclusive and additional materials may be used.

4.7.1 Ground Wire

Description: Bare or insulated (green) copper wire, 8 AWG, conforming to ASTM B 3.

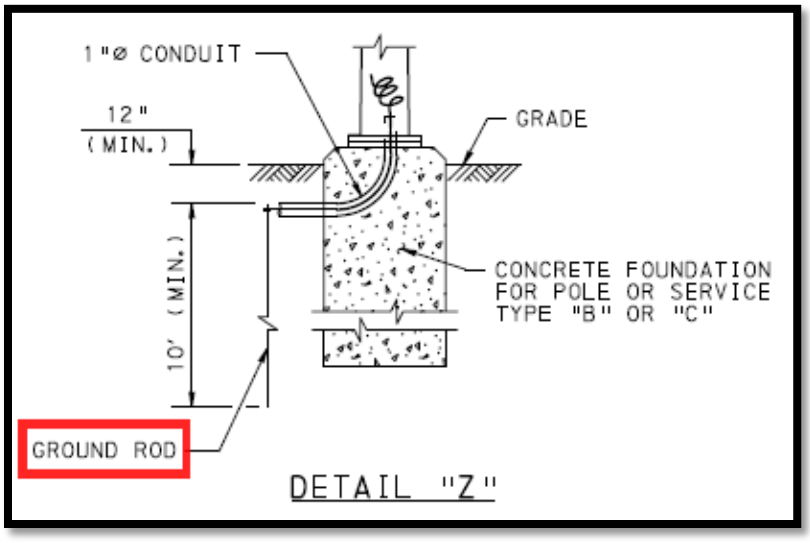
Use: Grounding wire for 120V AC circuits.



4.7.2 Ground Rod

Description: Copper-clad steel, UL listed. Provide with bronze clamp or exothermic weld for connection to grounding conductor.

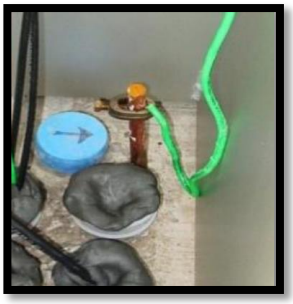
Use: Grounding rod for 120V AC circuits.



4.7.3 Ground Rod Clamp

Description: Ground wire clamp.

Use: Bronze clamp or exothermic weld for connection to grounding conductor.

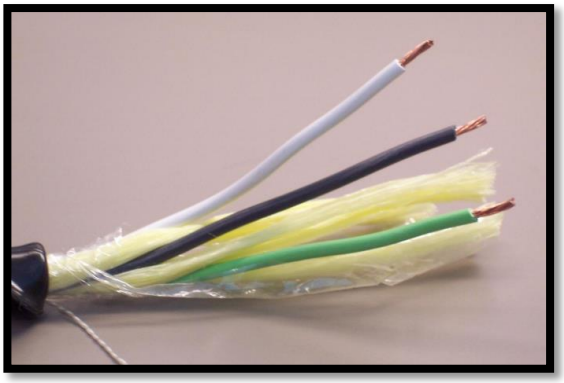


4.7.4 Conduit

Description: May be rigid steel or PVC

Use: Houses electrical conductors.

4.7.5 Signal Wire



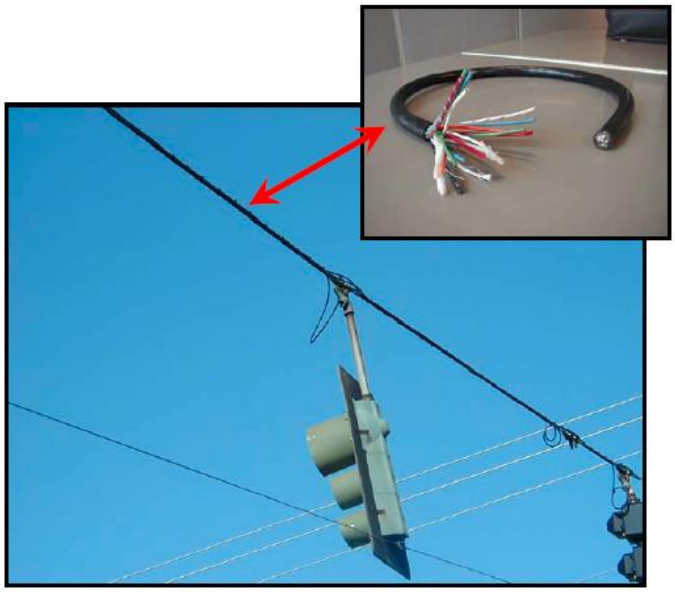
Description: 14 AWG minimum, stranded conductors; conforming to IMSA Specification 19-1 or 20-1.

THWN wire has PVC insulation and nylon jacket. Visually, this insulation is "shinier" than XHHW.

XHHW wire has cross-linked polyethylene insulation. This insulation is more durable than THWN.

Use: To provide electricity to equipment.

4.7.6 Control Cable



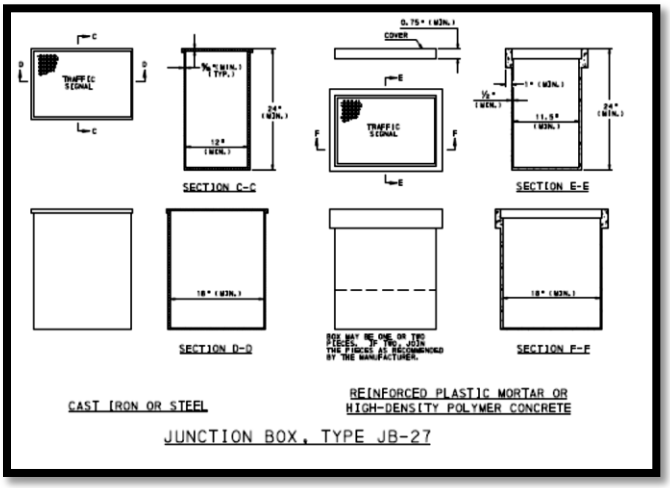
Description: Multi-conductor bundled cable with assorted stranded copper wires (typically 14 AWG, but may be other sizes). Must meet color code on standard drawings.

Use: Used to provide electrical energy. Strapped to messenger cable on spans, used in mast arms. May also be used in conduit runs.

4.7.7 Junction Boxes

Description: Watertight boxes of various materials, gasketed lid held down with stainless steel screws.

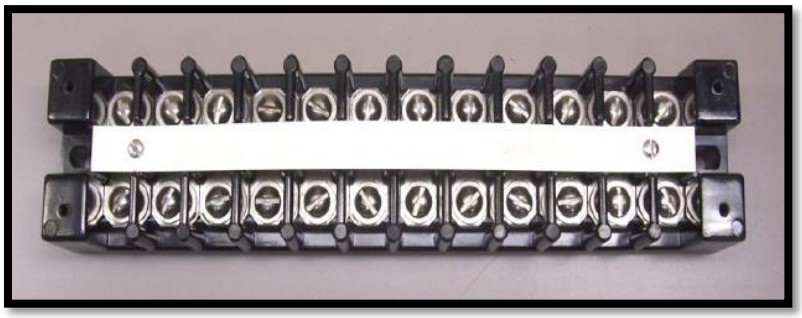
Use: The junction box is used as an access to conduit and wire. The lid can be removed.



4.7.8 Terminal Blocks

Description: UL-listed with twelve sets minimum to two terminals each, screw-type, rated at a minimum of 600 V, and suitable for the applicable wire size. Connect each set of terminals by means of a removable link. Separate each set of terminals by a molded barrier. Provide a marker strip for terminal identification.

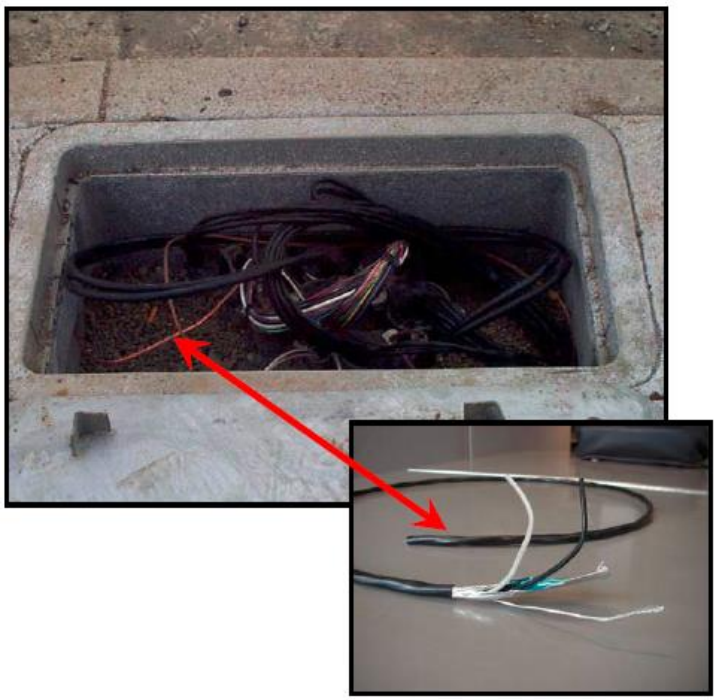
Use: For terminating wires/cables in signal pole or cabinet.



4.7.9 Loop Feeder Cable

Description: Polyethylene jacketed, shielded cable with two twisted No. 14 AWG wires and bare tinned copper drain wire or No. 14 AWG wires wrapped with mylar tape. IMSA Spec. No. 50-2. May also be No. 18 AWG wires if shown in the plans.

Use: Connects pairs of loop wires to controller, splice only at the junction box nearest the loop wires.



4.7.10 Loop Splice

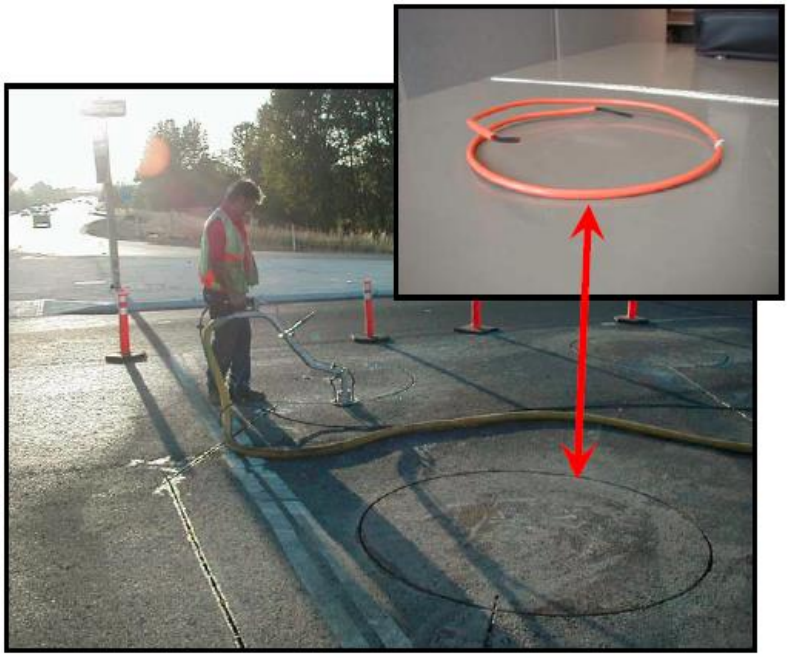
Description: Two-piece plastic enclosure flooded with silicon grease. Includes screw on silicon grease filled wire connectors.

Use: Used to connect loop feeder and loop wire (splice point).

4.7.11 Loop Wire (XHHW/DUCT)

Description: Stranded copper conductor, with crosslinked polyethylene insulation, No. 14 AWG wire. Encased in a polyethylene tube (sleeve). Wire and tube must be stamped with proper IMSA 51.7.

Use: Used to detect vehicles. Loop wire is installed in the pavement in a circle or diamond pattern. The pair of loop wires, from the pavement to the junction box, is manually twisted four to six turns per foot.



4.8 Traffic Signal Specific Materials

The following sections describe a variety of the commonly used traffic signal specific materials used on traffic signal projects. The list is not all-inclusive and additional materials may be used.

4.8.1 Aluminum Sign Mounting Framework

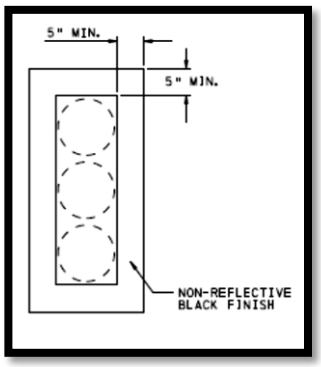
Description: An aluminum assembly for mounting signs on a mast arm and spanwire installations. Type A is a tenon/spanwire mount (typically only used for spanwire installations) and Type B is an adjustable bracket (without tenon) for mounting on mast arms and signal poles.

Use: To attach signs to a mast arm or span wire

4.8.2 Backplates

Description: Aluminum sheet powder-coated flat black louvered or black polycarbonate attached with stainless steel screws and washers with reflective sheeting along the edge.

Use: Shield around vehicle signal to provide a contrast to the background.

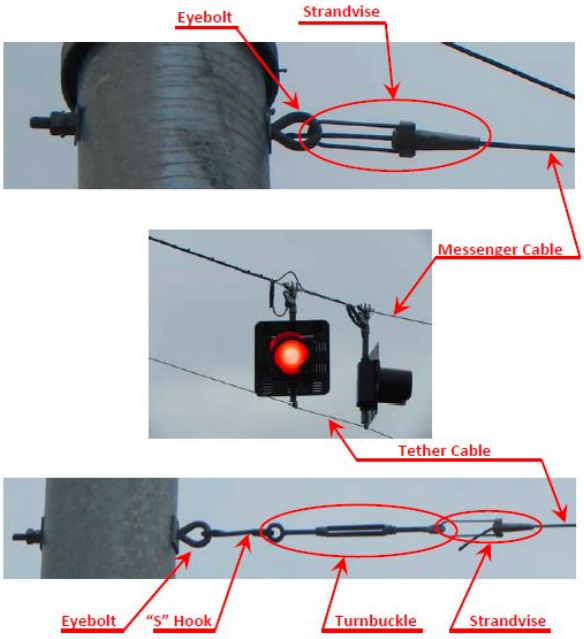


4.8.3 Eyebolt, Turnbuckle, Strandvise

Description: Hardware for attaching spanwire installations to strain poles.

Hot-dip galvanized.

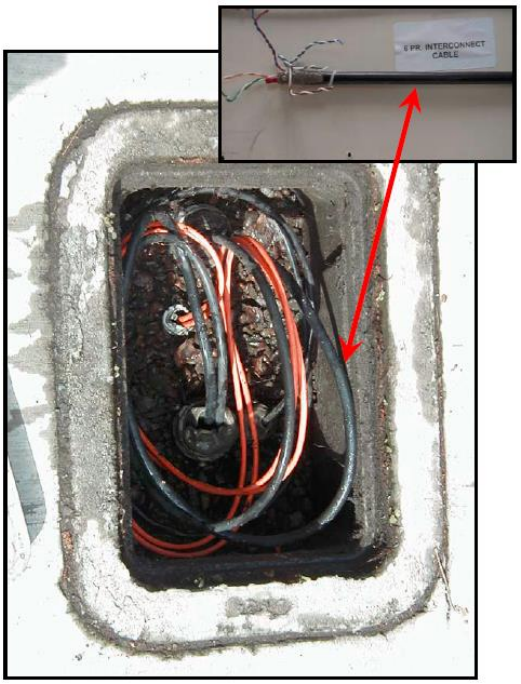
Use: An eyebolt and strandvise are used to hang the messenger cable (cable above signal heads). An eyebolt, "S" hook (state supplied, designed to yield if the tether cable is struck by a high load), turnbuckle and strandvise are used to hang the tether cable (cable below signal heads).



4.8.4 6-pair Interconnect Cable

Description: Shielded cable containing 6+ twisted pairs of No. 19 AWG wires. REA spec. PE-22 (air-core, for overhead) or PE-39 (gel-fill, for underground), polyethylene jacket.

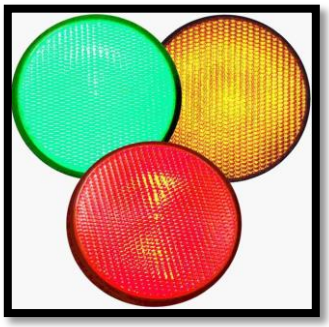
Use: For communication between traffic signal controllers. Installed with no splices between separate signal controllers.



4.8.5 LED Modules (Vehicle & Ped)

Description: Light Emitting Diode (LED) Unit which replaces incandescent bulbs in signal heads and pedestrian heads. Flange mount type, clear.

Use: To illuminate vehicle and pedestrian signals.



Section 1104 of Publication 408 indicates that the following must be Bulletin 15 approved:

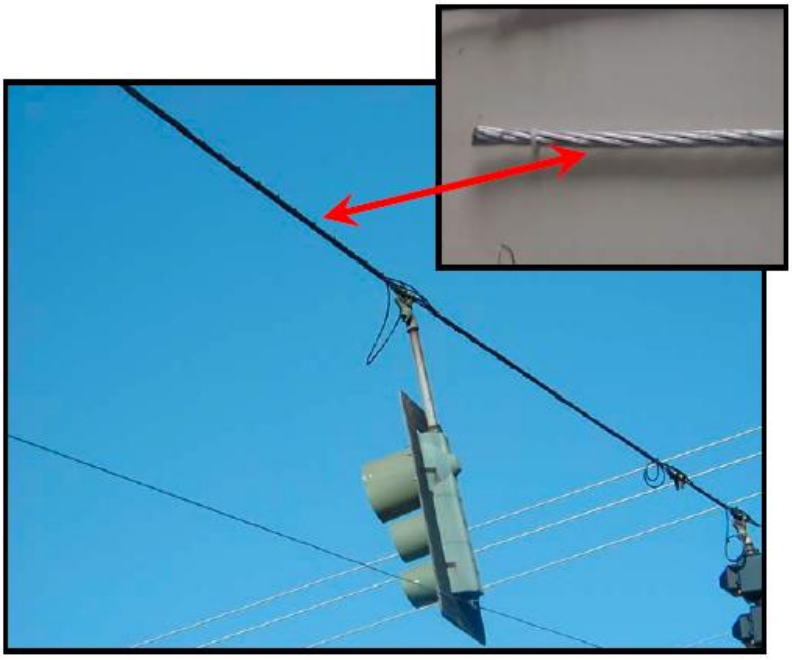
- ✓ LED Vehicular and Pedestrian Signal Modules
- ✓ LED Countdown Pedestrian Signal Modules
- ✓ LED Lane-Use Traffic Control Signal Heads

4.8.6 Messenger Cable

Description: Bare steel cable comprised of seven strands of galvanized wire.

Utilities grade 3/8-inch diameter with 11,500 lbs. break.

Use: Supports control cables, signal heads and signs on a spanwire installation.



4.8.7 Meter Base

Description: Socket into which the power company's meter is installed.

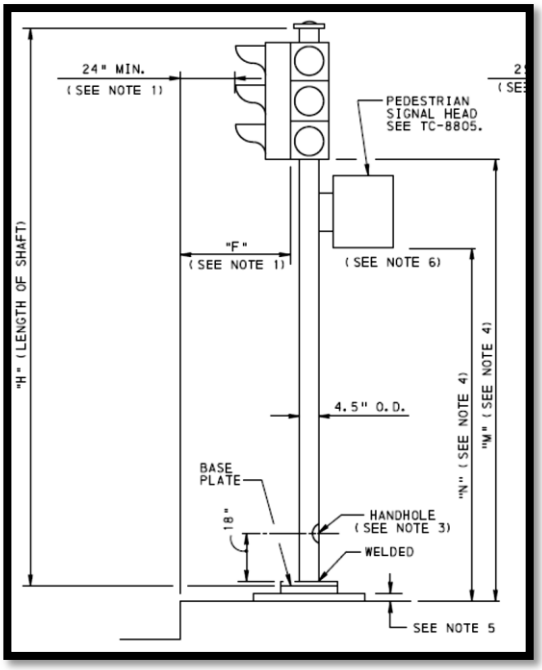
Stainless steel or powder-coated base.

Use: For power companies to meter power. Used between power source and service cabinet for temporary signals only (located on a temporary signal pole).

4.8.8 Pedestal (Pedestrian Signal)

Description: Galvanized steel pipe mounted on a cast aluminum or galvanized cast iron base.

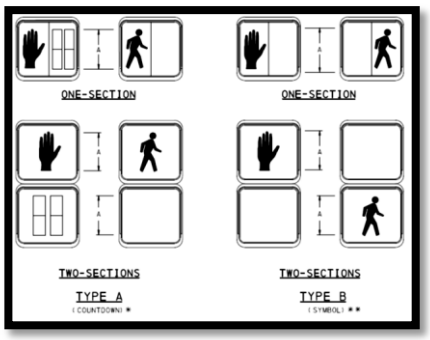
Use: Freestanding pole for mounting of pedestrian signals and/or traffic signal indications.



4.8.9 Pedestrian Signal

Description: Pole mounted signals. Aluminum powder-coated black or black polycarbonate with stainless steel hardware.

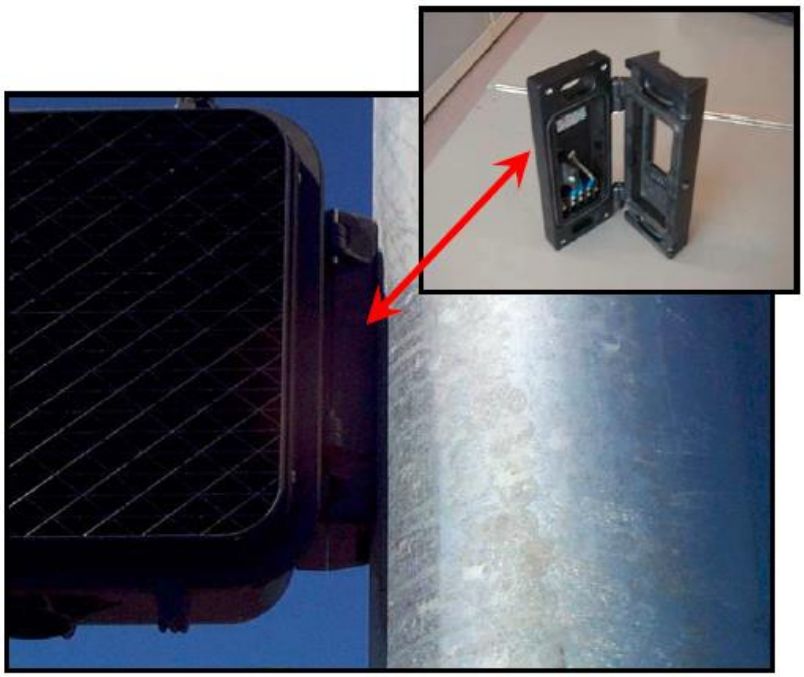
Use: To indicate walk/don't walk pedestrian phases at marked crosswalks.



4.8.10 Pedestrian Signal Mount

Description: Swing open clam shell compartment.

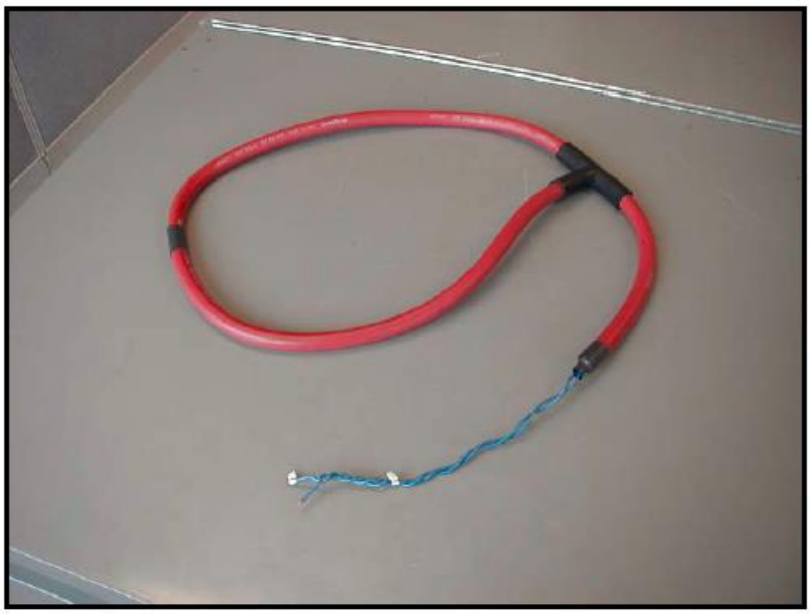
Use: To connect pedestrian signal to pole, with wire terminals.



4.8.11 Preformed Loops

Description: Four turns of No. 14 AWG XHHW or No. 16 AWG TFFN wire encased in either schedule 40 PVC or rubber hydraulic hose totally filled with sealant.

Use: Used to detect vehicles in thin, poor pavement or concrete bridge decks.



4.8.12 PTR Signs

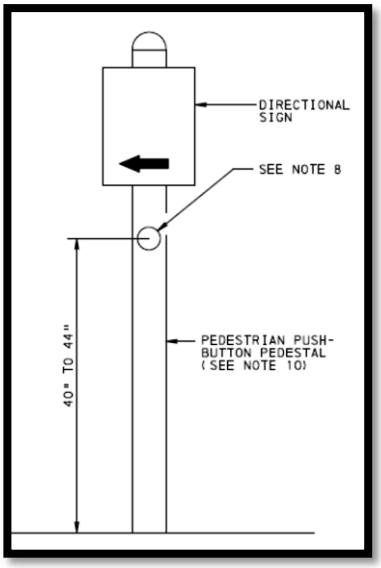
Description: Flat black, painted, aluminum alloy case with part-time legend when lit. LED illuminated legend.

Use: To indicate part time restrictions when turned on. Typically used at ramp meters, and for restricted turn moves when signals have railroad preemption.

4.8.13 Push Button

Description: A tamper and weatherproof assembly with pushbutton contacts, entirely insulated from the housing and buttons.

Use: For pedestrians to request the walk phase.



4.8.14 Riser Frames

Description: Aluminum framework of ¼" channel or 1/8" sheet stock.

One piece welded construction for newer installations; two-piece bolt together for retro-fit. Both styles anodized after fabrication.

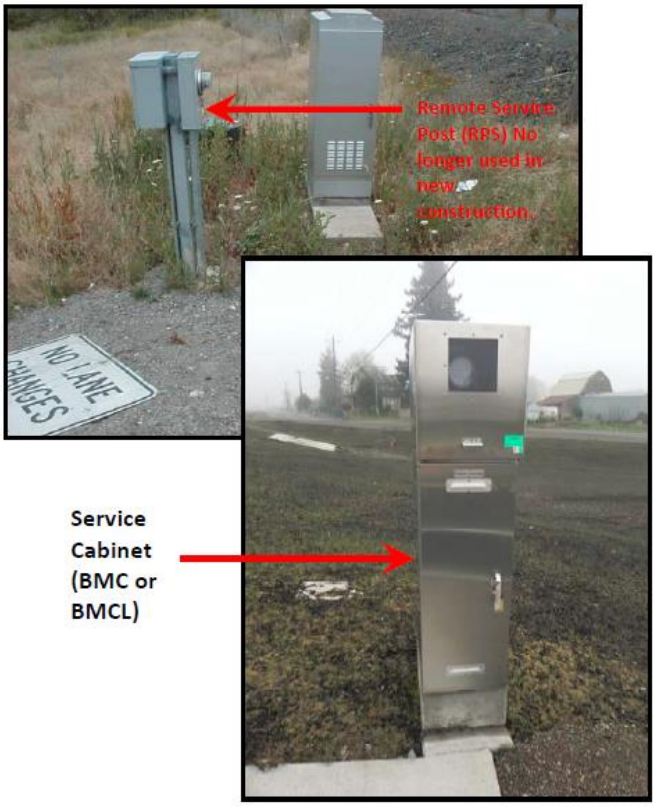
Use: To raise the controller cabinet from the foundation 8", providing additional work space under the cabinet. Use building paper gasket and nonhardening water tight seal between riser and cabinet and between foundation and riser.

4.8.15 Service Cabinet

Description: Base mounted service cabinet with integral meter base. Includes circuit breakers, contactors, test switches, neutral and ground bars.

Stainless, powder-coated aluminum, or galvanized steel cabinet.

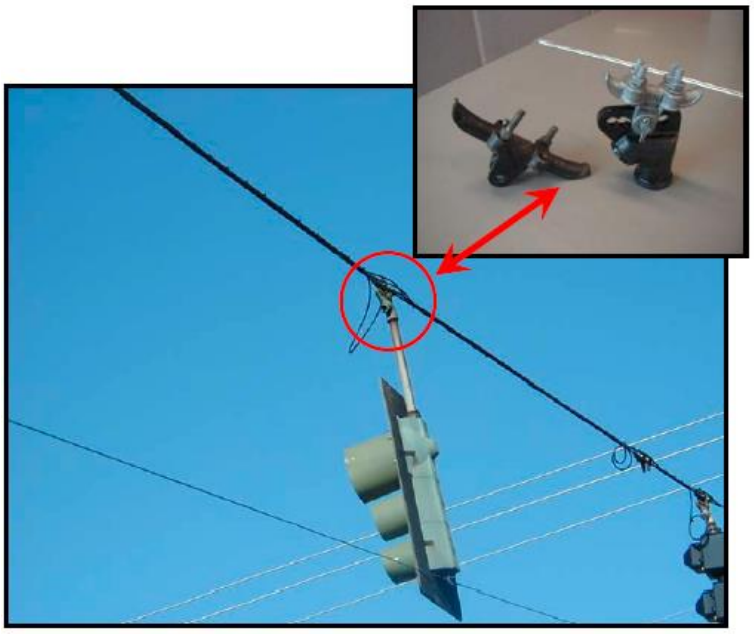
Use: Used to provide fused electrical service.



4.8.16 Spanwire Hanger

Description: A fitting of cast bronze that attaches to the messenger cable with two "U" bolts. A wire outlet body hangs from this with a clevis pin through adjustable slot. All fasteners shall be type 304/316 stainless steel.

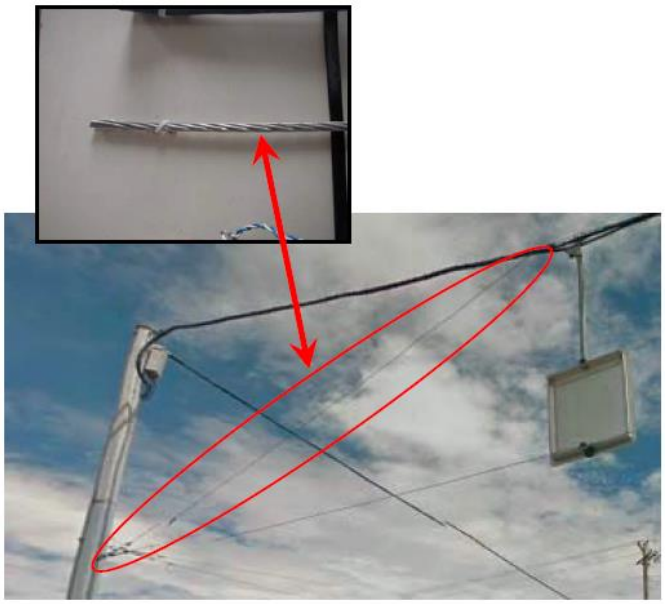
Use: To mount vehicle signal and signs on span wires. Allows equipment to hang plumb from spanwire, provides cable entrance when wire is installed with correct drip loop.



4.8.17 Tether & Stabilizer Cable

Description: One-quarter inch galvanized steel cable comprised of seven strands of galvanized wire. Class A coating conforming to ASTM A 475.

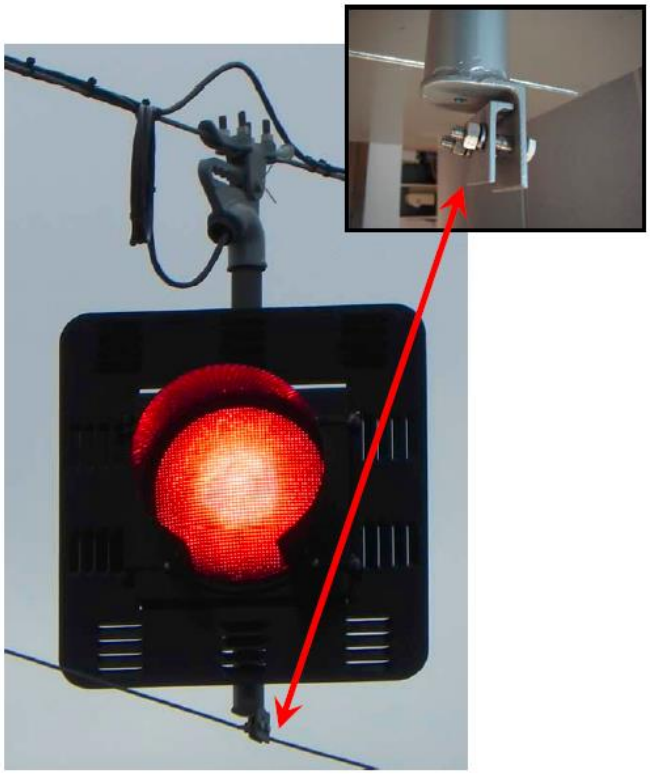
Use: Attached at the bottom of equipment to stabilize and prevent wind movement.



4.8.18 Tether Clamp

Description: Fitting on bottom of span mounted signal or sign constructed of 1½ inch galvanized steel pipe or galvanized metal conduit with plate welded on bottom, tether wire keeper bolted to plate. Galvanized after fabrication. All fasteners type 304/316 stainless steel.

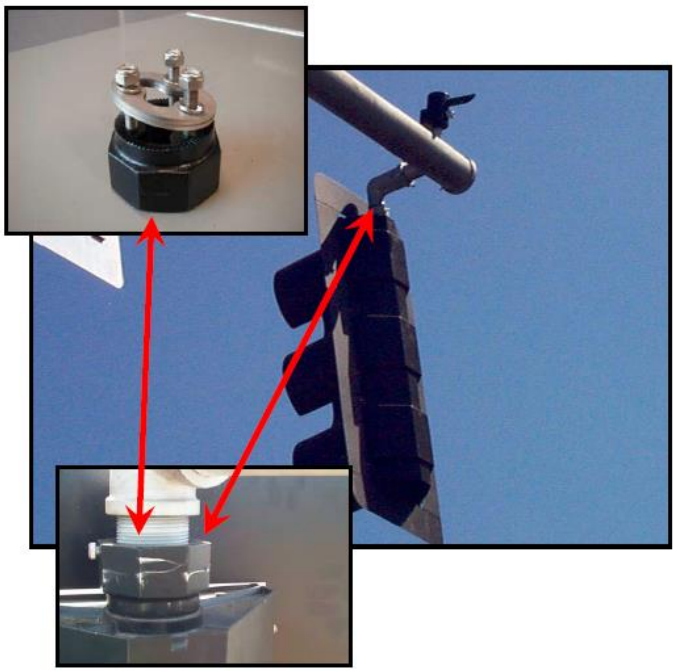
Use: To attach tether cable to vehicle signals and signs.



4.8.19 Tri-Stud Adaptors

Description: Fitting of cast aluminum with steel insert, powder-coated as per spec. Three bolts, split washers, nylon insert lock-nuts if stainless steel, with two stainless steel backing washers.

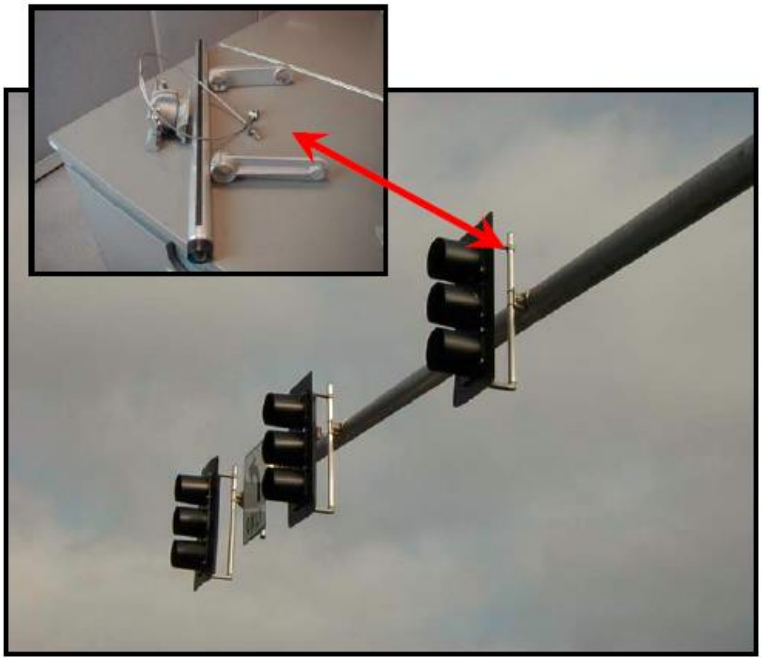
Use: To mount signals and signs to plumbizer or span wire hanger.



4.8.20 Vehicle Signal Bracket (Adj.)

Description: An extruded aluminum assembly that is adjustable. Its full length supports a vehicle signal on a mast arm and attaches to the arm by means of stainless steel cables.

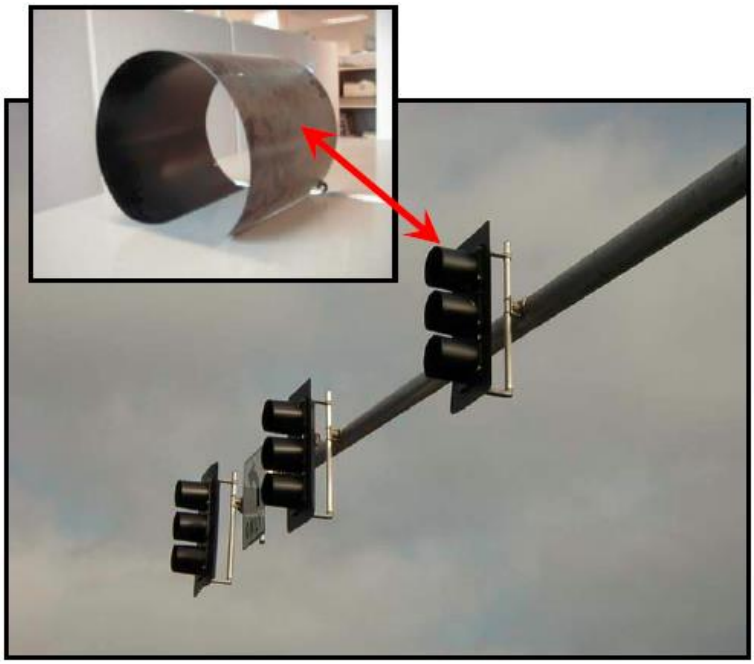
Use: To mount vehicle signals and signs on a mast arm. Allows for adjustment of signal for height and full support of signal sections.



4.8.21 Vehicle Signal Visor

Description: Aluminum powder-coated black or black polycarbonate open at bottom standard (tunnel). Visor must attach to signal heads with stainless steel screws.

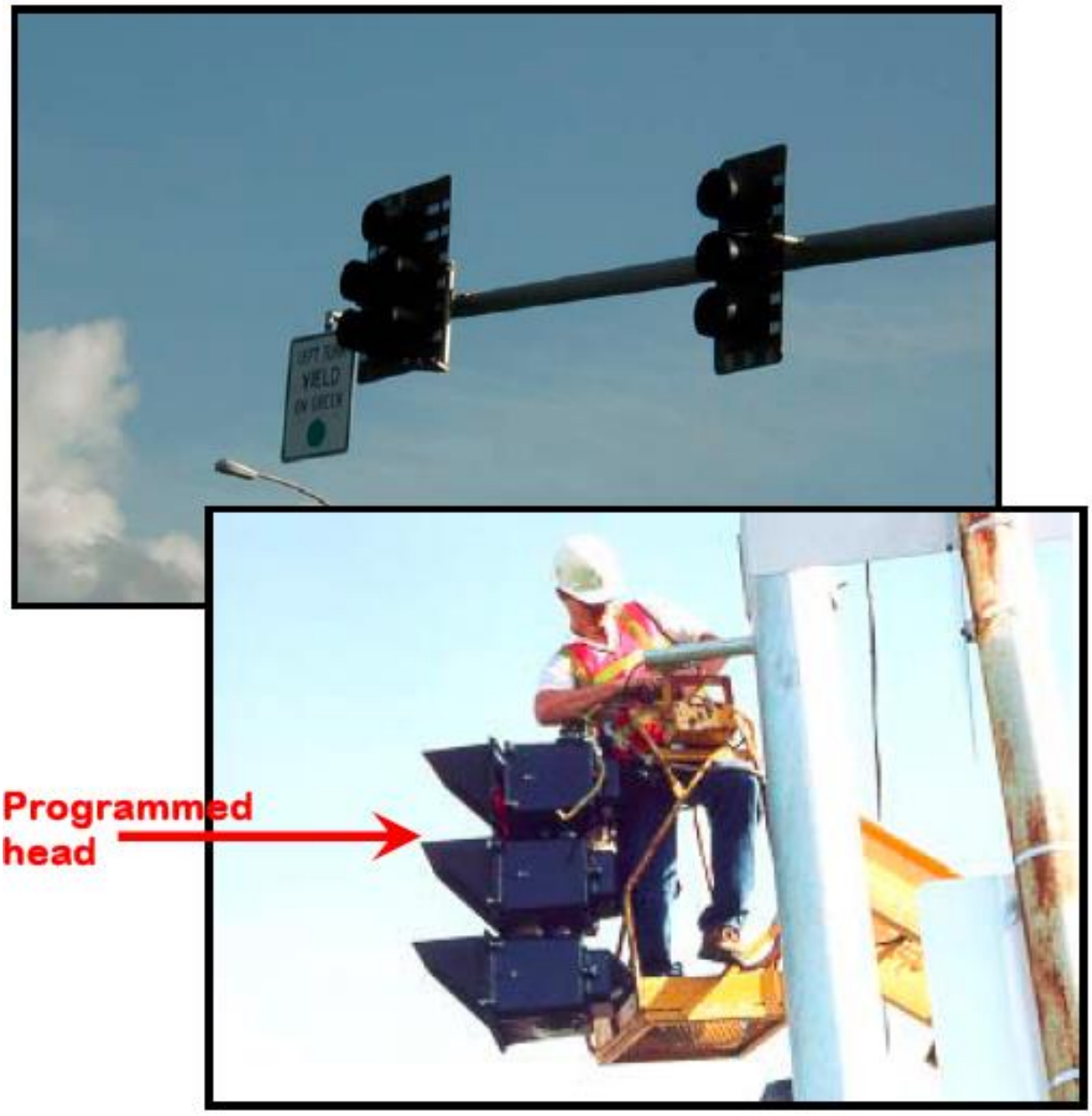
Use: On all signal heads to direct the illumination to the motorist.



4.8.22 Vehicle Signals

Description: Aluminum powder-coated black or black polycarbonate. May have 1,2,3,4 or 5 signal faces. May be programmable. All fasteners shall be type 304/316 stainless steel except for brass terminal screws.

Use: To direct vehicles at intersections.



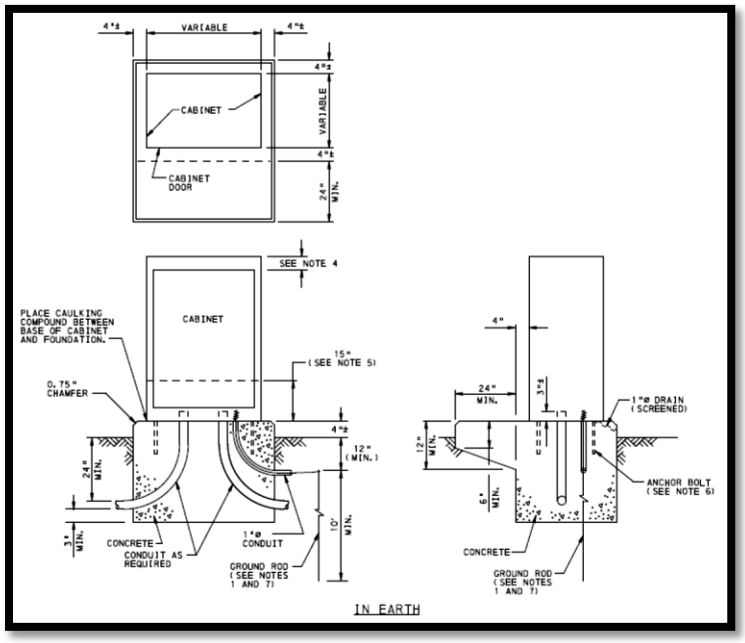
4.9 Traffic Signal Controller Materials

The following sections describe a variety of the commonly used traffic signal controller materials used on traffic signal projects. The list is not all-inclusive and additional materials may be used.

4.9.1 Controller Cabinet

Description: Ground mounted and pole mounted signal cabinets.

Use: Houses the equipment to run the traffic signal.



4.9.2 Controller

Description: NEMA or 170 controller unit.

Use: The brains of the traffic signal.

4.9.3 Conflict Monitor

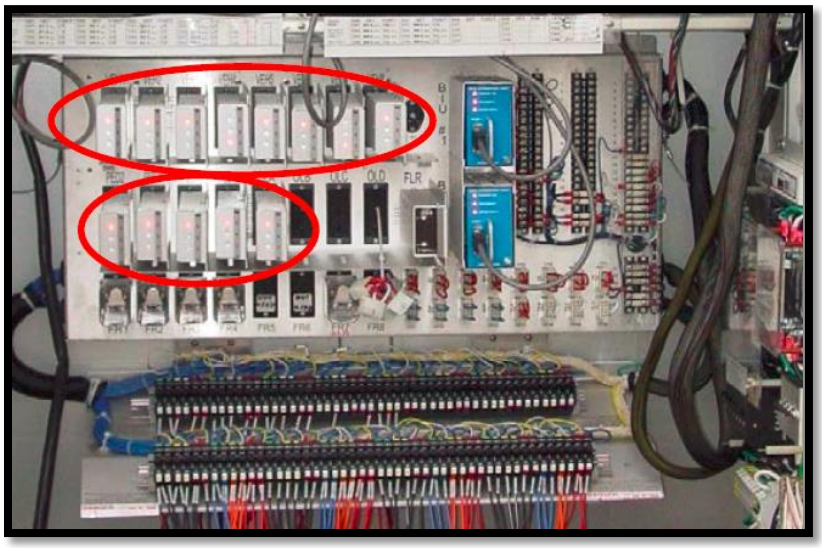
Description: NEMA or 170 as indicated in contract documents and Publication 408.

Use: Monitors the green indications (vehicle) and walk indications (pedestrian) to ensure conflicting movements are not serviced at the same time. Also monitors voltages.

4.9.4 Load Switch

Description: NEMA or 170 as indicated in contract documents and Publication 408.

Use: Powers the signal and pedestrian indications in the field.



4.9.5 Flasher

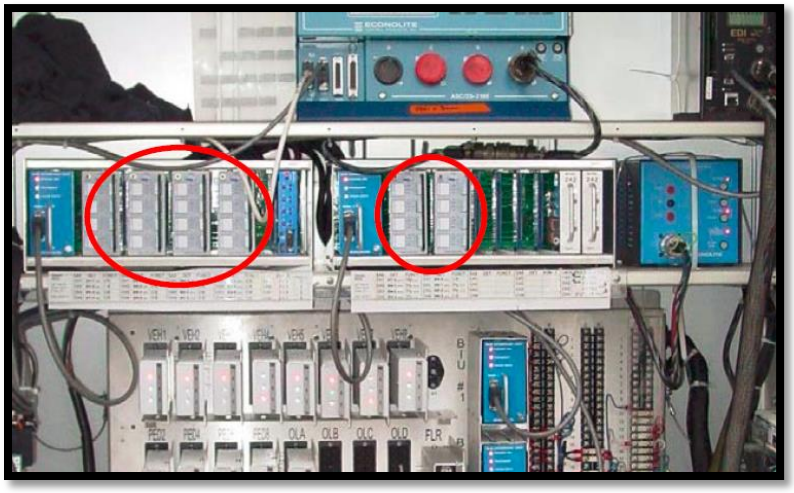
Description: NEMA or 170 as indicated in contract documents and Publication 408.

Use: Powers the signal indications when in flash mode.

4.9.6 Detector Amplifier

Description: NEMA or 170 as indicated in contract documents and Publication 408.

Use: A device that is capable of detecting the changes in the electrical energy produced by a sensor. Detects the change in inductance when vehicles move over a loop detector and places a "call" into the controller.



4.9.7 Isolator (DC and AC)

Description: NEMA or 170 as indicated in contract documents and Publication 408.

Use: Detects when a pedestrian pushes a button or when a train is approaching and puts a "call" into the controller.

4.9.8 Modem

Description: NEMA or 170 as indicated in contract documents and Publication 408.

Use: Provides communications between traffic signals and/or to the central traffic signal operations office.

4.9.9 Relay (FTR)

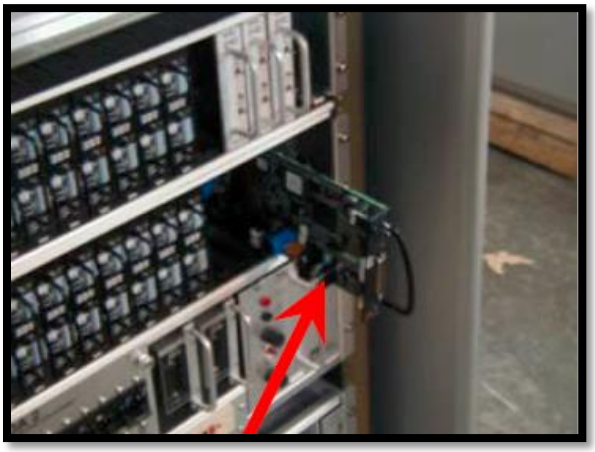
Description: Model 430

Use: Switches the power from the load switches (normal operation) to the flashers (flash operation).

4.9.10 Preemption Interface (Cabinet)

Description: Several models acceptable for use.

Use: Detects an emergency vehicle (that is using a preemption emitter in their vehicle) and puts a "call" into the controller.



4.9.11 Preemption Detector (Field)

Description: Several models acceptable for use.

Use: Detects an emergency vehicle (that is using a preemption emitter in their vehicle) which is recognized by the preemption interface in the cabinet.

4.9.12 GPS Time Sync Module

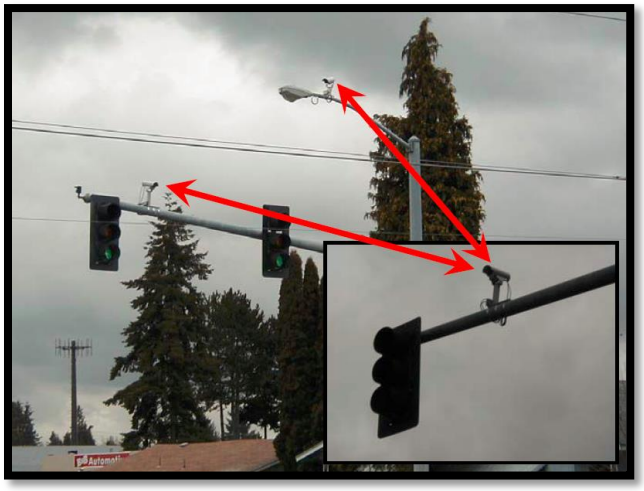
Description: Per Publication 408 Section 1104.

Use: To keep accurate time in the traffic signal controller. Accurate time is critical when the traffic signal is interconnected with other signals and/or operates in time-of-day, day-of-week plans.

4.9.13 Video & Radar Detection Device

Description: Camera mounted to mast arm or luminaire arm

Use: Alternative detection mode for vehicles.



4.9.14 Audible Pedestrian Signal

Description: Audio unit mounted near signal head and/or pushbutton.

Use: Provides sight impaired pedestrians' audible information regarding the pedestrian phases.

4.9.15 Battery Back-up System

Description: Uninterrupted Power Supply (UPS)

Use: Provides power to the traffic signal when commercial power is out.

CHAPTER 5. TRAFFIC SIGNAL CONSTRUCTION

In this chapter, typical procedures used in the installation of traffic signals are discussed. The methods used by each contractor or agency may vary; however, the basic procedures used for many items are common.

5.1 General

Traffic signals on commonwealth or local highways may be installed by contracts administered by the local authorities, municipal forces, contracts related to highway occupancy projects, or Department construction contracts.

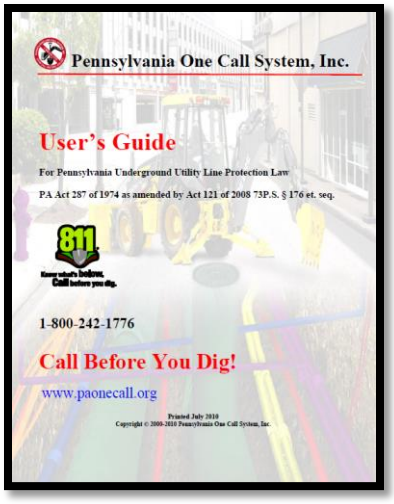
Local authorities are responsible for the inspection of the traffic signals that they have installed. The District office provides inspection for signals that are included in Department contracts or are installed in conjunction with Highway Occupancy Permits issued by the Department for work on state highways.

The District office reviews the completed permitted signal installation to verify that it complies with the signal permit requirements for signal design, controller operation, signing, and pavement markings.

Costs associated with the installation of traffic signals shall be the responsibility of the municipality where the signal is located unless the municipality enters into an agreement with another party who assumes all or part of these costs. Signal installation costs associated with Highway Occupancy Permit projects are generally funded by the permitee. The Department will participate in the cost to install or upgrade a traffic signal only when a Department construction project creates the need for a new signal or the need to revise an existing signal.

5.2 Pennsylvania One Call System

All excavators must contact PA One Call at least 3 business days prior to excavation, as required by law.



Pennsylvania One Call System is a non-profit Pennsylvania corporation created to protect the underground facilities before anyone begins to disturb the earth. PA One Call receives requests from excavators, contractors, plumbers, builders, designers, and the general public to find out where underground lines are located. Pennsylvania One Call notifies member underground facility owners of the intent to excavate. The member underground facility owner then marks where their lines are located.

The PUC representative on the Board of Directors of Pennsylvania One Call is the supervisor of the Gas Safety Section.

5.3 Traffic Control

Traffic control for signal projects is detailed in Publication 213 – Temporary Traffic Control Guidelines (see Section 2.10).

5.4 Staking

Locating the components of a traffic signal is not an exact science; many factors influence the location of the components. These factors include: lane widths, radii, crosswalks, cracks and joints in the pavement on existing roads and utilities below ground and overhead. It takes an experienced person approximately two to three hours to stake a signal. Using an experienced person to stake a traffic signal ensures efficient installation, easy maintenance and good operation. Exhibit 5-1 shows staking in the field for the location of a pedestal pole.

Exhibit 5-1 Staking in Field for Pedestal Pole

The primary considerations in staking a traffic signal are:

- ✓ **Lane widths and radii**. All thru lanes and turn lanes have to be measured prior to staking. On new construction, the lanes and the radii must be determined and laid out.
- ✓ **Location of crosswalks and pedestrian ramps**. Look at the plan and determine where the crosswalks and/or stop bars are located. Lay them out on the roadway. Many of the signal components are located relative to the crosswalks and stop bars. Keep in mind, median nose locations and existing sidewalks. The crosswalks and stop bars should be laid out parallel to the adjacent road and kept in a straight line from pedestrian ramp to pedestrian ramp. It is essential that they be established and tied in so that they can be relocated during all phases of construction.
- ✓ Signal poles are generally located on the back edge of the crosswalk or stop bar when possible. Check for utilities above and below ground.

- ✓ Loop detectors are located by measuring from the back edge of the crosswalk or stop bar.
- ✓ Non-Intrusive Detection, located on luminaire extensions, span wire, and/or mast arms as determined by the plan or engineer.
- ✓ Junction boxes are located opposite the loop detectors. Intermediate junction boxes are located equal distance between the loop detector junction boxes or conduit crossing junction boxes.
- ✓ Conduit crossings are located at specific junction boxes.
- ✓ Signal cabinet is located as shown on the plan and within the right-of-way.
- ✓ Source of power, which supplies electricity to service equipment for the signal.

5.5 Order of Installation

The following are some of the typical steps during the installation of a traffic signal. The actual steps and order may vary; however, this list provides some of the general steps.

Exhibit 5-2 Traffic Signal Construction Order of Installation

Step	Manual References
1. Install the signal supports	Sections 5.6, 5.7, 5.11 and 5.12
2. Install the underground conduit and junction boxes	Section 5.8
3. Install the controller cabinet and foundation	Section 5.10
4. Install the grounding system	Section 5.14
5. Install the electric power service	Sections 5.15 and 5.13
6. Install the span wire (if used)	Section 5.11
7. Install the signal heads and pull cable back to the controller	Section 5.13
8. Install the detection system and pull cable back to the controller	Sections 5.13 and 5.16

5.6 Mast Arm Installation

The primary difference between the installation of a mast arm assembly and a wooden pole (used for temporary traffic signal control and discussed in Section 5.8), is that the underground and above ground portions of a mast arm assembly are installed separately. First the mast arm foundation is installed, and then the mast arm assembly. A mast arm assembly is typically installed in the following manner:

1. Locate the position of the pole in the field and dig the hole
2. Prepare and set the reinforcing cage along with the anchor bolts
3. Install underground conduit
4. Pour the concrete
5. Wait for the concrete to cure
6. Use a crane or boom truck to set the vertical portion of the mast arm assembly (the mast arm pole) and secure the mast arm pole to the anchor bolts with hexagonal nuts
7. Use a crane to align the horizontal mast arm with the connection plate on the vertical pole and attach using hexagonal nuts
8. Level the assembly using the hexagonal nuts located at the base of the mast arm pole

It should be noted that the anchor bolts are set before the concrete is poured using the appropriate template shown in Publication 148.

Specifications for Traffic Signal Supports are covered in Publication 408, Section 951.3 and are shown below.

951.3 CONSTRUCTION— Sections 1104.01 and 1104.02, as shown on the Standard Drawings, and as follows:

(a) Excavation. Before forming and placing concrete, each foundation excavation will be inspected for the actual soil conditions encountered. Do not proceed with the work until the excavation is accepted. If necessary, revise the foundation design based on the soil conditions encountered. Before submitting the revised design for approval, obtain the signature and seal of a Professional Engineer registered in the State. Foundation locations may be changed to avoid underground obstructions, with written permission of the Representative.

(b) Foundations. Install reinforcement steel, anchor bolts, conduit sweeps, and ground rods with ground wire clamps. Orient the anchor bolt template to obtain the proper angle of the mast arm. Place concrete as specified in the applicable parts of Section 1001.3.

Backfill around the foundation in 150 mm (6-inch) layers with selected on-site material, then compact mechanically to the density of the undisturbed earth. Dispose of excess or unsuitable material. Place 12.7 mm (1/2-inch) premolded, expansion joint filler between the foundation and existing concrete sidewalks and pavements.

After placing concrete, do not install supports for a minimum of 72 hours.

(c) Traffic Signal Supports. Install supports, of the type indicated, on the foundation. Use leveling nuts on the anchor bolts to adjust the support shaft rake to provide a vertical set when the load is added.

Connect the ground wire to the grounding lug.

Install span and tether wires on strain poles. Allow enough span wire and tether wire length to fasten wire and for sag adjustment. After installing signal cable, signal heads, and signs, adjust sag of the span wire.

Install mast arm to column using high-strength bolts. Threaded plate traffic signal support connections are not allowed. Check for vertical alignment of the shaft and for alignment of the mast arm after signals, brackets, signs, luminaires, and signal cable are in place. Adjust to the correct alignment.

Tighten anchor nuts, as specified in Section 1105.03.

Place nonshrink mortar or metal screening, providing drain hole in the mortar or screening. Place mortar or screening vertically at the outside edge of the base plate.

As stated in Section 951.3(c), threaded plate traffic signal support connections are not allowed. This is a recent change to Publication 408.

5.6.1 Mast Arm Features

Mast arm assemblies are typically constructed of either steel or aluminum. The assembly is bolted to a reinforced concrete foundation which gives the assembly additional structural stability. The mast arm and mast arm poles are hollow and the cable from the signal heads passes through the inside of the mast arm and mast arm pole to conduit located in the concrete foundation, and then through this conduit to external conduit that takes the signal cable back to the traffic controller cabinet.

Exhibit 5-3 includes two pictures of a mast arm assembly. **Exhibit 5-4** is a sample of the traffic signal support – mast arm assembly from Publication 148, TC-8801 sheet 1 of 10.

Refer to Publication 408, Standard Specifications section 1104.02 for additional details. For example, Section 1104.02(a) indicates:

(a) General.

1. Design and Acceptance. Design in accordance with Publication 149. Submit shop drawings in accordance with Publication 149, including calculations for all special structures, for review and acceptance.

Shop drawings can be found on the PennDOT Traffic Signal Portal.

Exhibit 5-3 Mast Arm Assembly

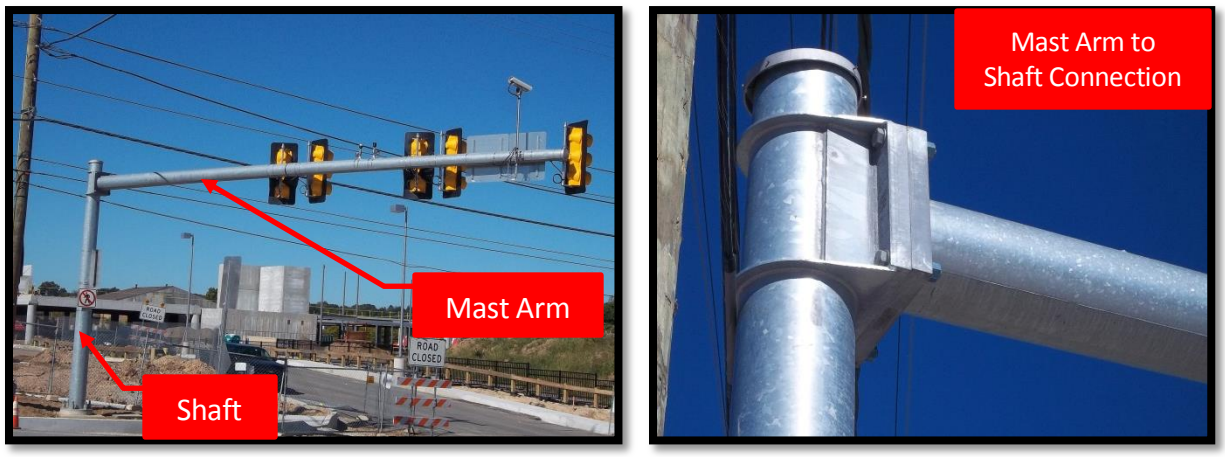
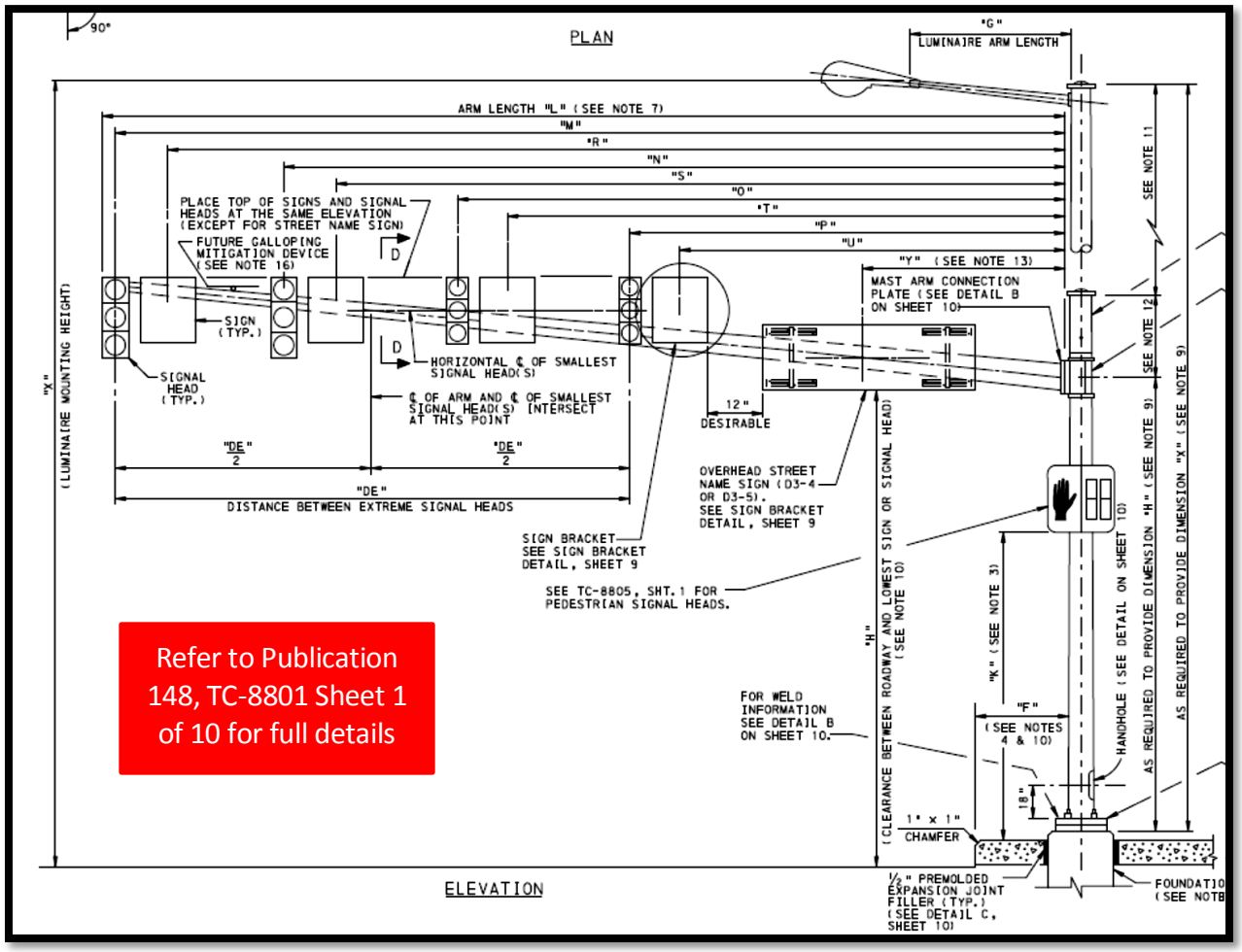


Exhibit 5-4 Publication 148 TC-8801 Sample-Traffic Signal Support Mast Arm Assembly



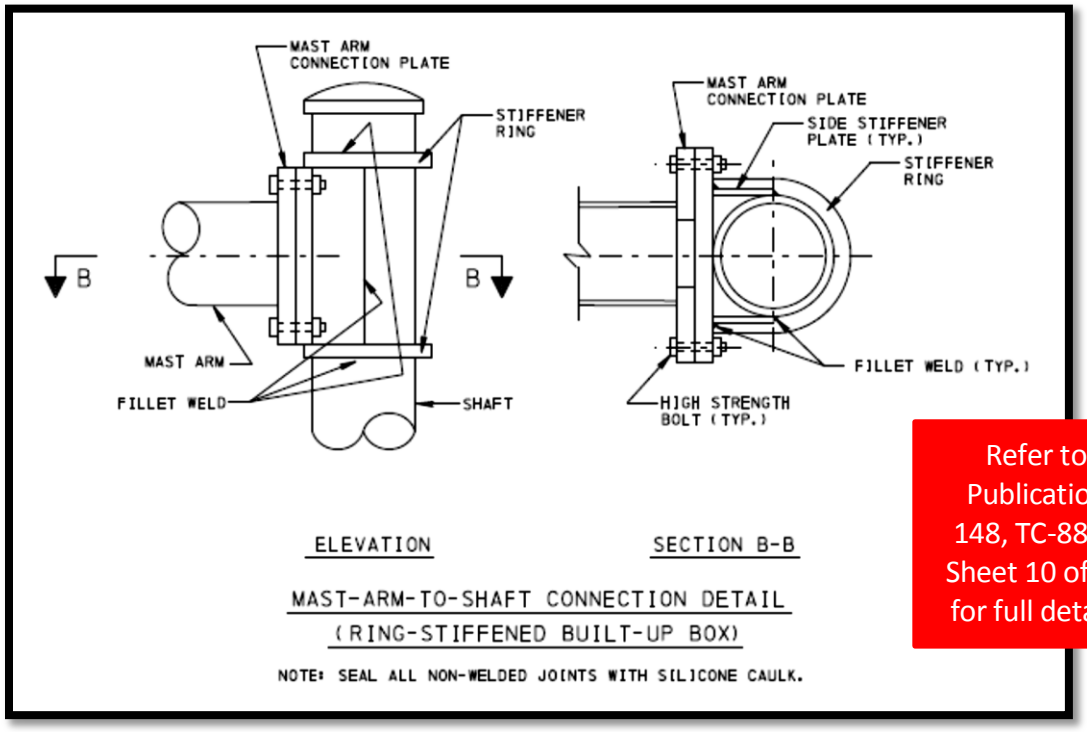
5.6.2 Above Ground Components

The above ground portion of the mast arm assembly consists of two major components:

1. The mast shaft, which is the vertical component that provides structural strength.
2. The mast arm itself, which is the horizontal component on which the signal heads are mounted.

The mast arm is typically bolted to the shaft. This attachment usually occurs in the field, which makes it easier to transport the assembly to the site. **Exhibit 5-5** is from Publication 148, TC-8801 sheet 10 of 10 and shows the mast arm to shaft connection detail. **Exhibit 5-3** includes a close-up picture of a mast arm to shaft connection.

Exhibit 5-5 Publication 148 TC-8801 Mast-Arm-to-Shaft Connection Detail



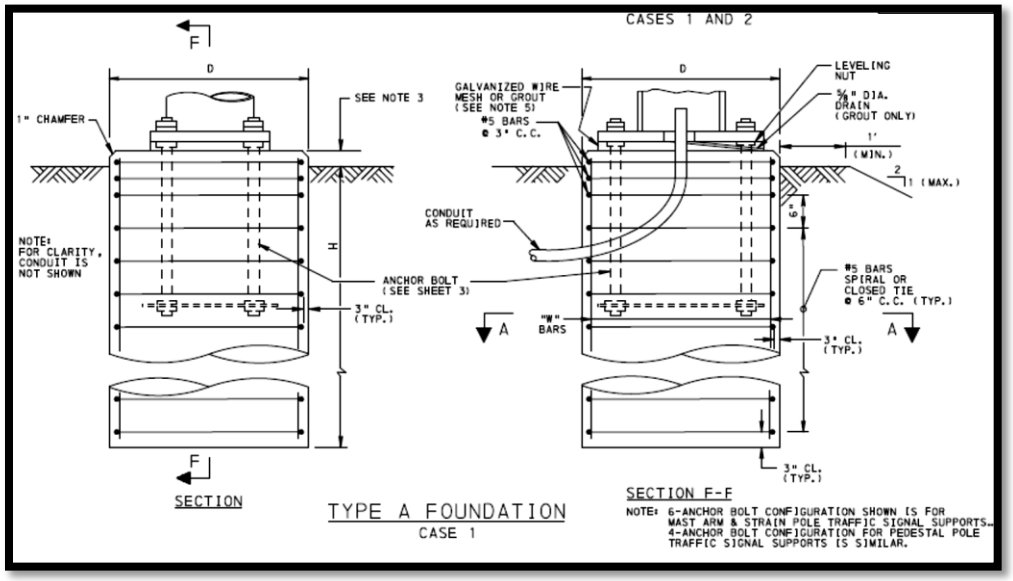
Refer to Publication 148, TC-8801 Sheet 10 of 10 for full details

5.6.3 Mast Arm Foundation

The mast arm foundation is composed of concrete with steel reinforcing. The size and shape of the foundation is as specified in Publication 148, TC-8801 or the contract documents. Anchor bolts, which are embedded into the top of the concrete foundation, are used to attach the mast arm pole to the foundation. It should be noted that mast arm foundations typically extend deeper than concrete strain foundations. **Exhibit 5-6** shows a mast arm shaft mounted to a concrete foundation via anchor bolts. **Exhibit 5-7** shows a portion of Publication 148, TC-8801 page 4 of 10 regarding foundation notes and anchor bolt details.

Exhibit 5-6 Mast Arm Shaft Foundation

Exhibit 5-7 Publication 148 TC-8801 Foundation Detail



Preparing the Cage

The steel reinforcing in a mast arm foundation is commonly referred to as "the cage." The cage is prepared by attaching large vertical reinforcing bars using smaller circular tie bars. The first step in the mast arm installation process is to assemble the cage and then, using a crane, to place the cage into the mast arm hole. Exhibit 5-8 is a picture of a foundation cage and anchor bolts for use in the concrete foundation and Exhibit 5-9 is the closed tie detail from Publication 148, TC-8801 sheet 4 of 10.

Exhibit 5-8 Foundation Cage and Anchor Bolts

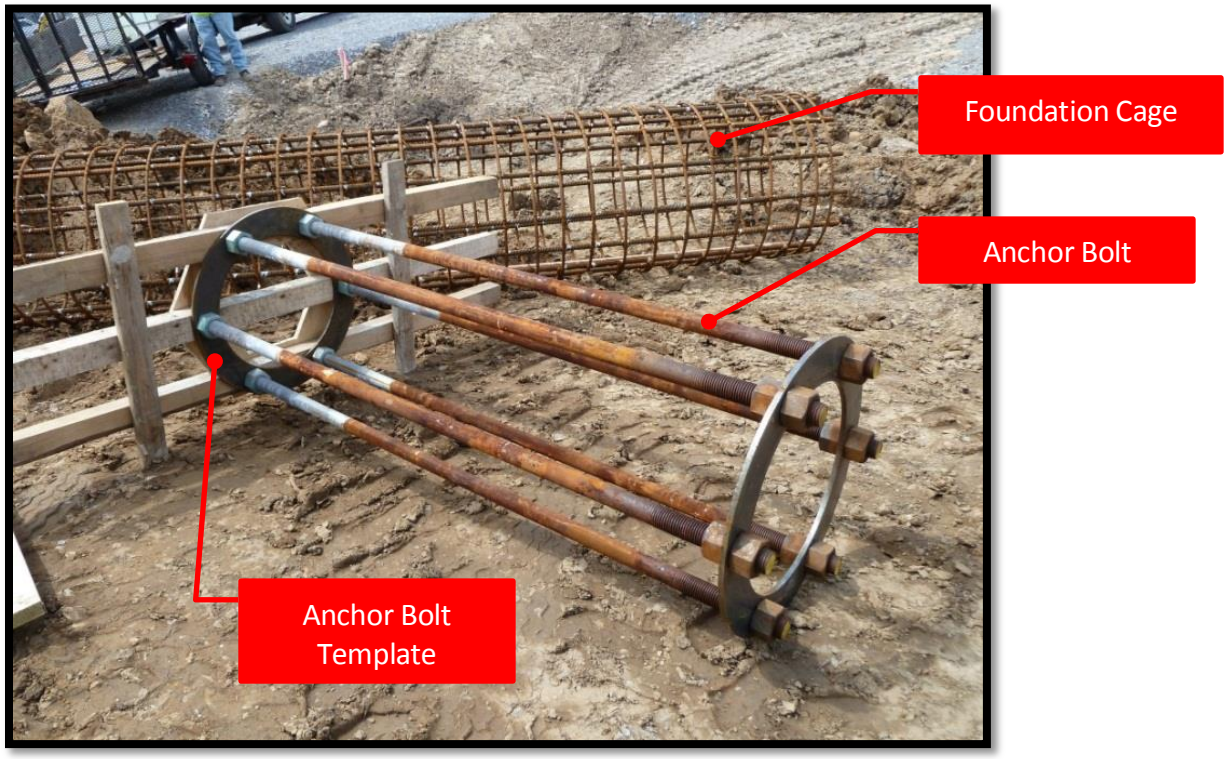
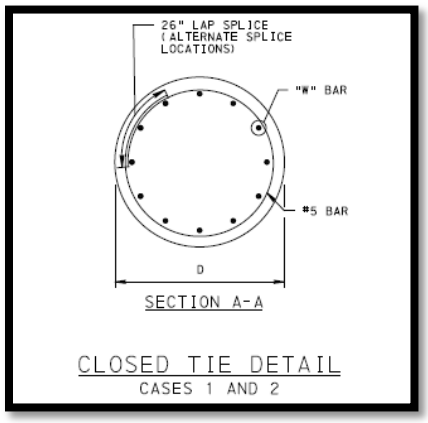


Exhibit 5-9 Publication 148 TC-8801 Closed Tie Detail



Fix the Pole Position

Using the plans as a guide and making note of the location of underground utility lines (as marked by the utility companies), the final location of the poles is established. Although some field adjustment of the pole is usually allowed to avoid utilities, the pole cannot be moved too close to the street or outside the right-of-way (see Section 5.4 regarding Staking).

Hand Dig the Hole

Since utilities are not always properly located, and since unknown utilities are sometimes present at a site, it is good practice to hand-dig the first few feet of the hole for the signal pole. Encountering unknown utilities with a shovel is much less destructive than drilling through them with an auger.

Dig Rest of the Hole

The remainder of the hole is then dug with automated auger equipment (see Exhibit 5-10) until the required hole depth is achieved. During the excavation, a pump can be used to remove excess water that might accumulate in the hole. The pump has a protected intake so that dirt will not be sucked into the pump mechanism, which could ruin it.

Exhibit 5-10 Automated Auger Digging Foundation Hole and Auger Truck

Hole Stabilization

If the sides of the hole are unstable, then measures must be taken to ensure that the hole will not collapse. This is usually done in one of two ways:

A. By inserting a sleeve into the hole, either permanently or temporarily, to support the sides of the hole or,
B. By applying mineral slurry (commonly referred to as “drilling mud”) to the sides of the hole. The slurry reacts with the soil on the sides of the hole to form a cohesive surface that reduces the possibility of cave-in.

Types of Sleeves

Two types of sleeves are commonly used: metal sleeves and sleeves made of pressed cardboard coated with wax. If conditions permit, the metal sleeve can be removed from the hole and reused. On the other hand, the pressed cardboard sleeve must remain in the hole; it cannot be removed and reused.

Setting the Cage

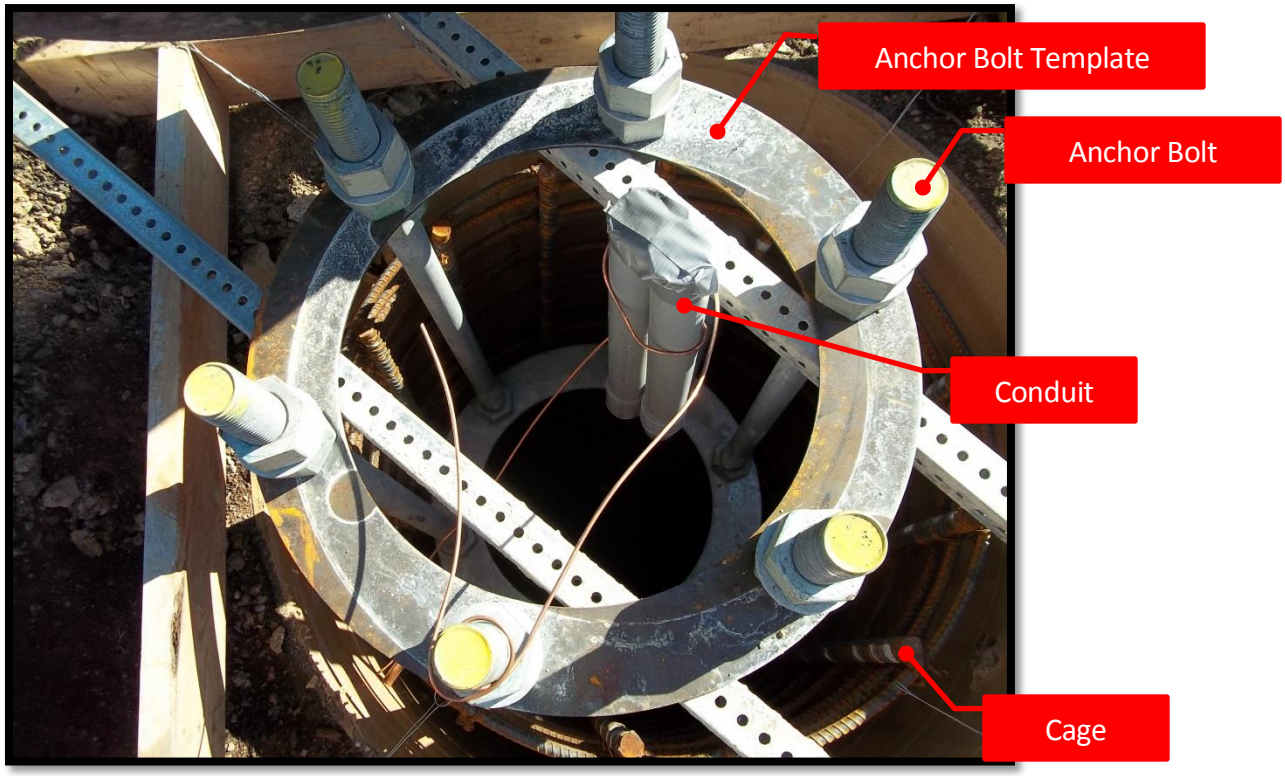
Once the hole is dug and stabilized, the cage is then suspended into the hole using wooden supports and concrete is poured around and through the cage until all voids are filled. The wooden supports are then removed as the concrete cures. **Exhibit 5-11** is a picture of the foundation cage being lowered into hole with the use of a crane. **Exhibit 5-12** is a picture of the foundation structure prior to the concrete pour.

Exhibit 5-11 Setting the Foundation Cage

Installing Conduits

Before the concrete is poured, all conduits entering the foundation must be installed. A spare conduit can be placed in the mast arm foundation to accommodate the grounding wire or for future expansion. **Exhibit 5-12** also shows the conduit covered with tape to prevent concrete entry.

Exhibit 5-12 Foundation Cage and Anchor Bolts



Anchor Bolt Template

A template (refer to **Exhibit 5-12** for a picture) provided by the pole manufacturer, which contains the desired configuration and spacing of the anchor bolts, is used to determine the exact location of the bolts prior to pouring the concrete. **Exhibit 5-13** shows the anchor bolt Publication 148, TC-8801 Standard drawing showing the anchor bolt details.

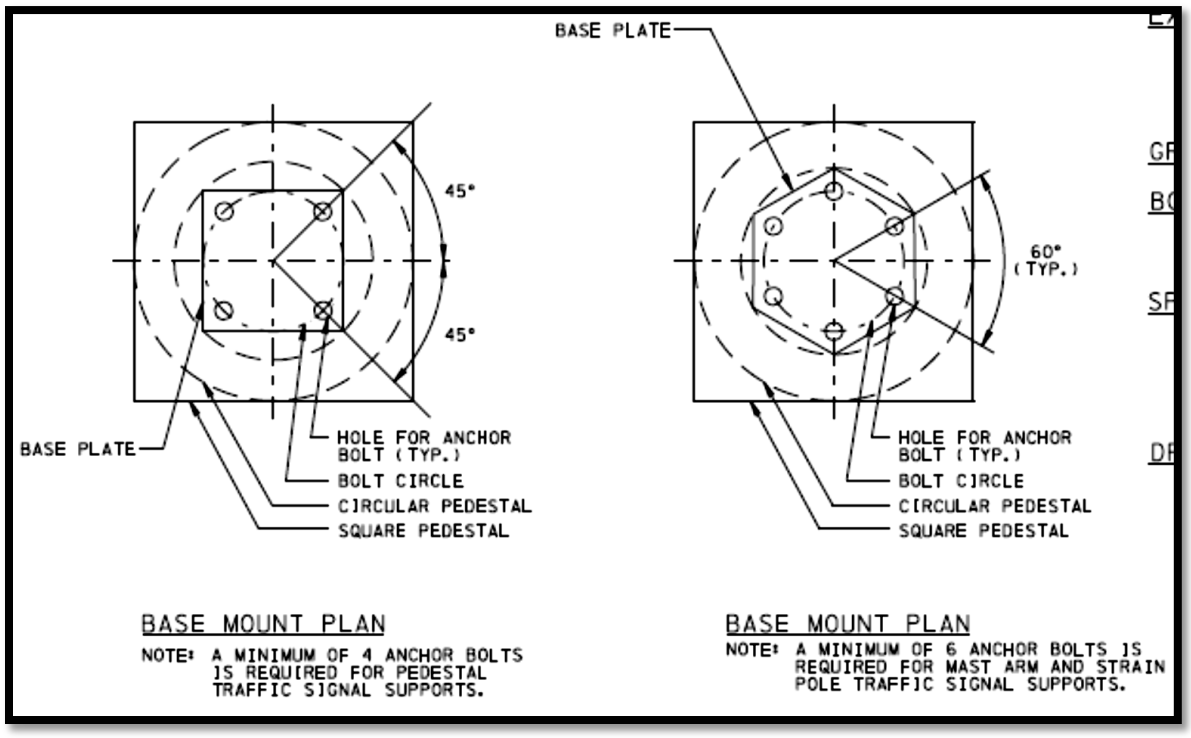
Setting the Anchor Bolts

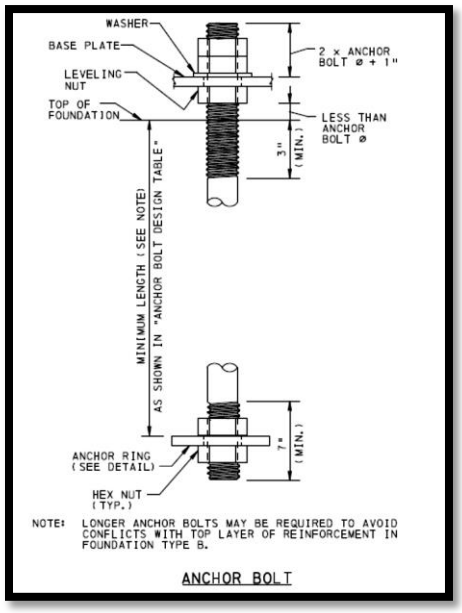
The anchor bolts are placed in the foundation cage prior to the concrete pour (see **Exhibit 5-12** for a picture). The length left protruding above the top of the foundation is as shown in Publication 148. The required length, diameter, and orientation of the anchor bolts are provided in Publication 148 or the approved mast arm shop drawings.

Taping the Threads

Some agencies tape the threaded ends of the anchor bolts prior to the concrete pour so that splashes of concrete do not damage the threads.

Exhibit 5-13 Anchor Bolt Design Standard Drawing Sample





ANCHOR BOLT DESIGN, MAST ARM

MAST ARM LENGTH	QTY.	ONE ARM				TWO ARMS *			
		DIA.	LGTH.	B.C.	HOLE	DIA.	LGTH.	B.C.	HOLE
0 - 10′	6	1¾"	35"	18"	2"	1¾"	35"	18"	2"
>10′ - 15′	6	1¾"	35"	18"	2"	1¾"	35"	18"	2"
>15′ - 20′	6	1¾"	35"	18"	2"	1¾"	35"	18"	2"
>20′ - 25′	6	1¾"	35"	18"	2"	1¾"	35"	18"	2"
>25′ - 30′	6	1¾"	35"	21"	2"	1¾"	35"	21"	2"
>30′ - 35′	6	1¾"	35"	21"	2"	1¾"	35"	21"	2"
>35′ - 40′	6	2"	40"	24"	2¼"	2"	40"	24"	2¼"
>40′ - 45′	6	2"	40"	24"	2¼"	2"	40"	24"	2¼"
>45′ - 50′	6	2"	40"	24"	2¼"	2"	40"	24"	2¼"
>50′ - 60′	6	2"	40"	24"	2¼"	2"	40"	24"	2¼"

Anchor Bolt Orientation

Use of the anchor bolt template (base plate) ensures that the holes in the bottom of the mast arm pole will properly align with the anchor bolt protruding from the foundation. However, this does not ensure that, when the mast arm pole is attached to the anchor bolts, the mast arm will be oriented properly with respect to the street. Proper orientation of the mast arm is ensured only if the anchor bolts themselves have been properly oriented with respect to the street, and this must be done before the anchor bolts are set into the foundation and the concrete is poured. More than one mast arm base has been re-poured because a mistake was made in the orientation of the anchor bolts.

Exposed Anchor Bolts

Until the pole is in place, barricades should be placed around the foundation to protect vehicles and pedestrians from the protruding anchor bolts. Injury could occur if someone were to trip and fall on the anchor bolts.

Top of the Foundation

Although at many intersections the top of the mast arm foundation should be installed at ground level, this may not be true in all cases. Especially in rural areas, the designs may call for the top of the foundation to be above ground level so that the horizontal portion of the mast arm will be high enough in relation to the surface of the street. Careful consideration must be paid to this issue or the signals will be too low. It is good practice to have these elevations established by a survey crew.

Concrete Curing

Per Publication 408, Section 951.3(b):

(b) Foundations. Install reinforcement steel, anchor bolts, conduit sweeps, and ground rods with ground wire clamps. Orient the anchor bolt template to obtain the proper angle of the mast arm. Place concrete as specified in the applicable parts of Section 1001.3.

Backfill around the foundation in 150 mm (6-inch) layers with selected on-site material, then compact mechanically to the density of the undisturbed earth. Dispose of excess or unsuitable material. Place 12.7 mm (1/2-inch) premolded, expansion joint filler between the foundation and existing concrete sidewalks and pavements.

After placing concrete, do not install supports for a minimum of 72 hours.

5.6.4 Setting the Mast Arm Pole

A typical 21' steel shaft (the vertical portion of the mast arm assembly) weighs less than 1500 lbs. A crane is used to lift the pole and, with the assistance of a person on the ground, the pole is guided onto the anchor bolts.

Protecting From Nearby Electrical Lines

Electrical lines that are in close proximity to support poles (or to span wires) will typically be "rubberized" during construction. A line is rubberized when the utility company places a high visibility non-conductive sleeve (sometimes referred to as "line hose") around the wire. These sleeves not only reduce electrical conductivity but also make the line highly visible to construction personnel, including crane and bucket truck operators. However, it should be emphasized that the sleeves do not provide full protection from electrical currents and care must still be taken to avoid contacting electrical lines.

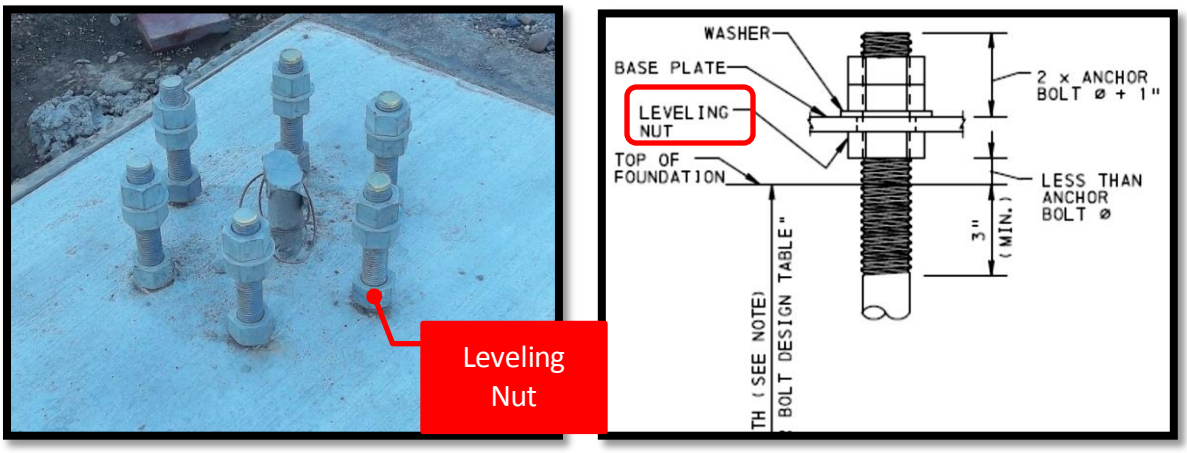
5.6.5 Securing the Mast Arm Pole

The mast arm pole is then secured to the foundation by a series of hexagonal nuts that are attached to the anchor bolts (see **Exhibit 5-6** and **Exhibit 5-7**).

5.6.6 Leveling Nuts

On each anchor bolt, a hexagonal nut is placed below the base plate of the mast arm pole. By adjusting the relative position of these nuts, the vertical orientation of the mast arm pole can be slightly altered. Once the mast arm and signal heads have been attached to the mast arm pole, these leveling nuts (also known as leveling shims) can be used to adjust the final vertical position of the mast arm and signal heads. Ensure that leveling nuts are in a snug-tight condition with the bottom of the base plate. Snug-tight is defined as the full force of a man on a 12-inch wrench.

Exhibit 5-14 Leveling Nut Picture and Standard Drawing Sample



5.6.7 Attaching the Mast Arm

Since a 40' steel mast arm also weighs less than 1500 lbs, only a small crane is needed to lift up the horizontal portion of the mast arm to meet the mast arm pole to attachment. Hexagonal bolts are used to secure the mast arm to the mast arm pole at the attachment plate (see **Exhibit 5-4** and **Exhibit 5-5**).

5.6.8 Mast Arm Sag

The amount of sag of the mast arm depends on the stiffness of the mast arm, with stiffer mast arms having less sag. Sag that is 2% of the mast arm length is typical. Consequently, 50' mast arm will usually have about 1' of sag.

5.6.9 Orienting the Mast Arm

Most mast arms are designated to resist loading in a particular direction and the mast arm must be installed so that the correct side faces upwards. If the mast arm is installed sideways or upside-down, the arm will experience an excessive amount of sag.

5.6.10 Proper Handling of Mast Arms

Mast arms must be properly handled during installation to ensure that members are not inadvertently bent and to ensure that portions of the galvanized or painted surface are not accidentally scraped off. However, even with careful handling, a certain amount of touch-up is usually required.

5.6.11 Wind Effects on Unloaded Mast Arms

If a mast arm is left for an extended period of time with no load on it (in other words, with no signal heads attached), a steady wind can cause the arm to oscillate. If this oscillation continues for a sufficient length of time, the arm may weaken and even break. Consequently, mast arms should not be left in an unloaded condition except for short periods of time.

5.6.12 Oscillation Dampers for Galloping Mitigation

Oscillation due to wind effect can be a problem even with loaded mast arms. To reduce wind effect, some agencies install oscillation dampers to the mast arm (see **Exhibit 5-15**, Exhibit 5-16 and **Exhibit 5-17**).

Exhibit 5-15 Publication 148, TC-8801 Information on Galloping Mitigation

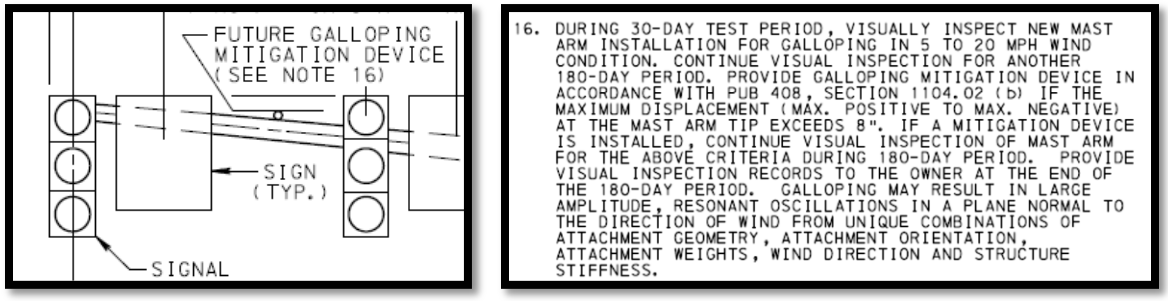


Exhibit 5-16 Publication 148, TC-8801 Mitigation Device Detail

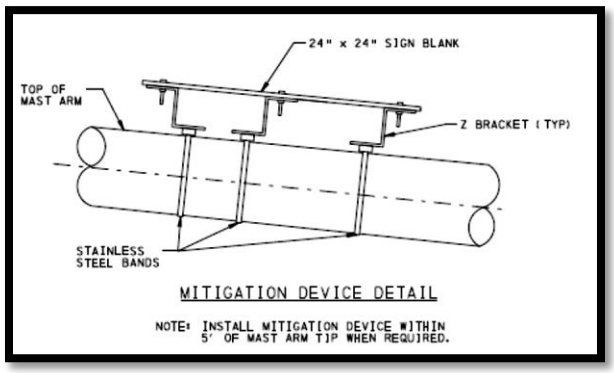
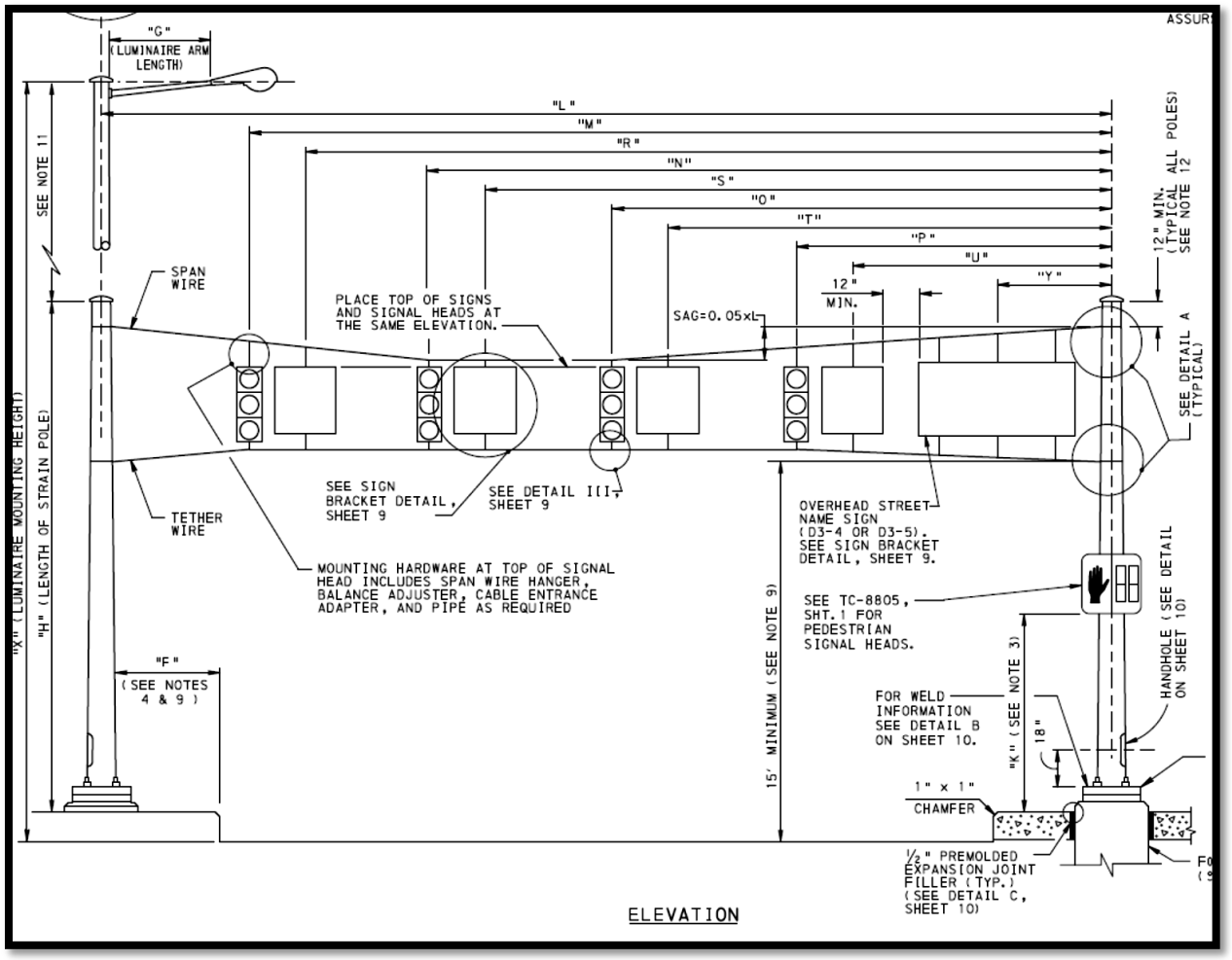


Exhibit 5-17 Wind Oscillation Damper

5.7 Steel Strain Pole Installation

The installation of a steel strain pole occurs in a manner very similar to that for mast arm poles, with a reinforced foundation being poured before the pole is set. As with mast arms, leveling nuts are also used on steel poles to adjust their vertical alignment in order to obtain the desired degree of rake.

Exhibit 5-18 Publication 148, TC-8801 Traffic Signal Support – Strain Pole Sample



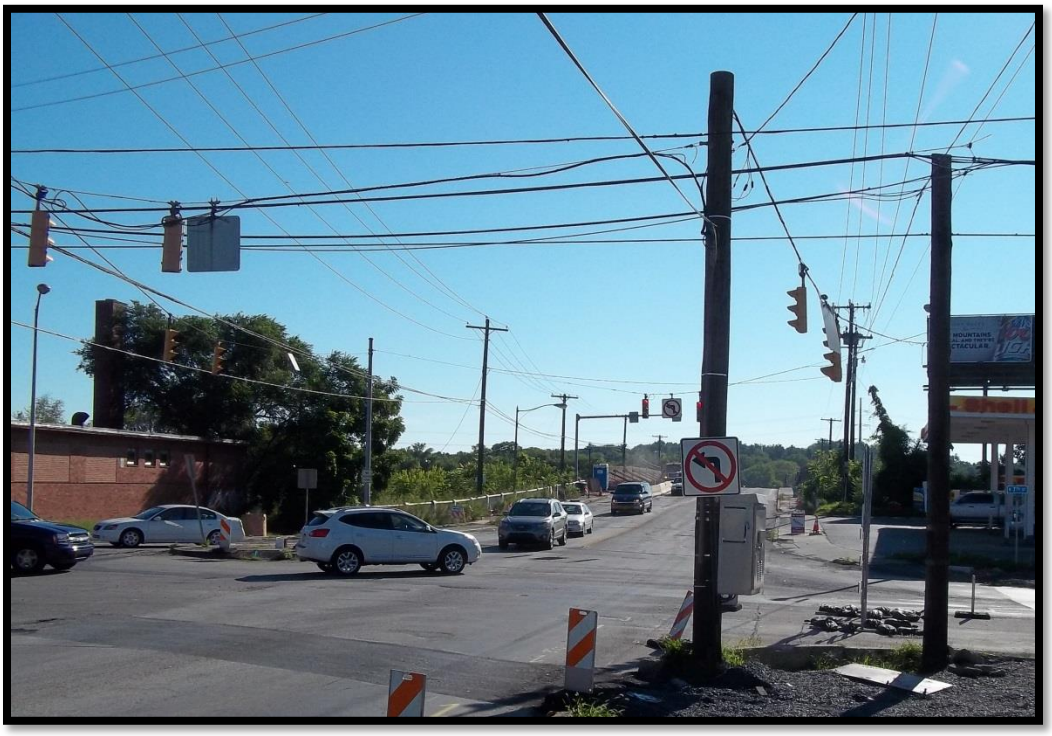
Raking the Pole

Strain poles are usually installed so that they are tilted slightly away from the direction of the load. The pole manufacturer usually specifies the amount of tilt, which is referred to as the "rake" of the pole.

5.8 Install Wooden Signal Supports

In the commonwealth, wooden poles are typically used for temporary traffic control signals. Refer to Publication 408, Section 1124 for specifications.

Exhibit 5-19 Wooden Signal Supports (Temporary)



5.8.1 Wood Strain Pole Installation

A wood strain pole is typically installed using the following tasks:

1. Fix the position of the pole in the field (see the section on staking, Section 5.4)
2. Hand-dig first few feet of the hole
3. Dig the remainder of the hole using an auger
4. Use crane to remove pole from delivery truck and set in hole
5. Install underground conduit
6. Backfill hole with concrete or tampered dirt
7. Allow concrete to strengthen before loading the poles

Wooden Pole Features

Wooden poles are typically made out of treated timer and are essentially the same type of pole used by many utility companies to support overhead wires. The wooden pole is buried in the ground and conduit attached to the outside of the pole is used to run signal cable from the span wires to underground conduit.

Wooden Pole Classes

Wooden poles come in 10 classes, with class 1 poles being the strongest and class 10 poles being the weakest. The stronger poles have larger diameters and are made of sturdy wood such as pine or chestnut. Class 5 wooden poles are frequently used in traffic signal construction.

Backfilling the Hole

Once the pole is in position, the hole is then backfilled with either dirt or concrete. If dirt is used, then the backfill must be placed in layers and compacted to ensure that proper soil strength is achieved.

Dealing with Water Intrusion

If ground water seeps into the hole, then it will either need to be pumped out prior to pouring the concrete or special concrete will need to be used that can be placed in water.

Supporting the Pole

While filling the pole foundation hole with dirt or concrete, the pole must be supported by the crane until sufficient foundation strength is achieved. Alternatively, a pole support stand can be used to hold up the pole, freeing-up the crane to perform other tasks or to leave.

Guying Wooden Poles

Wooden poles are usually guyed opposite the load on the pole to provide additional structural support. Special expandable or screw-type anchors are inserted into the ground to hold the guy wire in place. The anchors should be placed in-line with the guy wire to properly resist the load.

Guy Anchors

Guy anchors come in various sizes and configurations depending on the desired holding capacity of the guy wire assembly. Single-helix, and concrete block (“slug”) configurations are available for use, with variations obtainable in the diameter of the helix and the size of the slug. The higher the number of the helix, or the larger the slug, the greater the holding capacity of the anchor.

5.9 Junction Box and Conduit Installation

Junction boxes and conduits are used as raceways for carrying signal cable, loop wires, and communication cable to the controller cabinet. Conduits for traffic signal installations are usually referred to in one of three ways that are related to the conduits' location: above ground conduit, underground, or under pavement conduit.

Exhibit 5-20 Junction Box in Concrete and Dirt

Exhibit 5-21 Conduit in Trench and Sample PVC

5.9.1 Junction Box Features

A junction box is an underground storage compartment, typically rectangular in shape, with no bottom and a removable cover. Conduits enter the junction box through the open bottom, or through knockouts in the side of the box, and the cable carried by the conduits is exposed inside the junction box. A traffic signal junction box is usually made from either concrete or a polymer concrete mixture and has either a concrete, polymer concrete, or metal cover.

Publication 408, Section 1104.05(b) indicates the following regarding junction boxes:

(c) Junction Box. Furnish the type indicated and as follows:

- Precast Junction Box—Section 714
- Steel or Cast-Iron Junction Box—steel or cast iron conforming to the requirements for cast-iron junction box, Section 1101.10.
- Reinforced Plastic Mortar Junction Box—Provide heavy duty junction box with nonskid surface and a watertight connection to the housing. Provide a minimum design load 15,000 pounds with a test load of 22,500 pounds. Place a logo "Traffic Signal" on cover.

Additional, Publication 408, Section 910.3(p) is as follows:

(p) Junction Boxes. Obtain acceptance of any change in box location before installation.

Excavate, then construct or install the box. Backfill around the box and dispose of excess or unsuitable material. Ground the junction box as required.

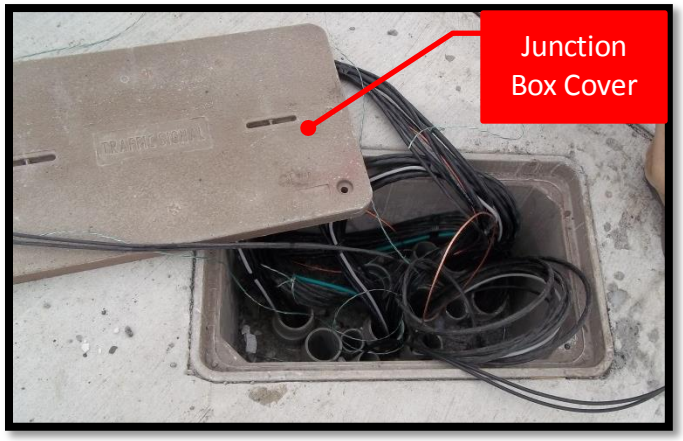
If using precast junction boxes with knockouts, remove the knockouts, then tightly grout the conduit or conduit sleeves in place with nonshrink mortar.

Ground exposed metal parts of junction boxes with a minimum 21.15 mm2 (No. 4 AWG) ground wire and a minimum 12 mm x 2.5 m (1/2-inch by 8-foot) ground rod. Connect the ground wire to the ground rod with either an exothermic weld or with a bronze connector clamp. Connection to an adjacent system ground rod is allowable.

5.9.2 Junction Box Covers

The cover of the junction box usually contains a lifting slot, which allows it to be easily removed with a hand tool (such as a large screwdriver or a pry bar). The cover may also contain bolts that can be used to secure the top to the junction box. Even though junction boxes are usually not installed in streets or driveways, the cover should be strong enough to support the weight of a vehicle. It is not uncommon to encounter flimsy plastic junction box covers that have been destroyed by vehicles that have left the road and crushed them.

Exhibit 5-22 Junction Box Cover



Install Flush

The junction box cover should be installed flush with the ground or sidewalk and should have a non-skid surface so that pedestrians do not trip or slip on them.

5.9.3 Gravel for Drainage

Pea gravel is often installed in the bottom of the junction box to promote the drainage of any water that might accumulate in the box. The end of the conduit should extend above the pea gravel so that stones do not find their way into the conduit; stones which can chafe the wire.

Don't Pinch Cables

The end of the conduit in the junction box should not extend too high such that, when the lid is put on, the cables emanating from the conduit are pinched between the lid and the end of the conduit.

Add Duct Seal

Conduits entering the junction box may be protected against water intrusion by inserting duct seal into the conduit and forming it around the wires.

Label All Wires

All of the cables or wires found inside the junction box should be properly labeled as to type (loop, signal, communications, etc.) and destination.

5.9.4 Junction Box Use

Junction boxes are typically used where the direction of the conduit changes, at points where the conduit enters poles or cabinets or, in the case of long conduit runs, where access to the cable is needed for installation purposes. Excess cable is sometimes stored within a junction box for future use.

5.9.5 Extra Large Junction boxes

A standard traffic junction box is about 2' x 1' x 1'. However, junction boxes come in various sizes and extra-large junction boxes are available with dimensions such as 3'x2' x 1.5'. With the increasing use of fiber optic cable for signal communication purposes, extra-large junction boxes – which can accommodate the larger bending radius of fiber optic cable – are becoming more common. An extra "loop" or two of fiber optic cable is often placed in these junction boxes to provide "slack" for repairs should the cable be severed.

5.9.6 Schematic Nature of Junction box and Conduit Locations

The location of junction boxes and conduit runs usually has some flexibility, with the locations shown on the plans being approximate in nature. In order to avoid utilities and facilitate construction, the final location of junction boxes and conduits usually ends up being a little different than the location shown on the plans. This is quite acceptable as long as the intended function is provided.

5.9.7 Distance Between Junction boxes

If junction boxes are spaced too far apart, it becomes difficult to pull cable through the conduit that connects them, which can result in cable damage. On the other hand, if junction boxes are spaced too closed together, the contractor ends up wasting a lot of time as he or she goes from junction box to junction box, pulling the wire in inefficient short segments. In addition, more junction boxes are required and the cost of the project is needlessly increased if junction boxes are spaced too close together. For long conduit runs, a spacing of around 400' between boxes is typical. With fiber, it is possible to go longer distances.

5.9.8 Conduit Installation

Underground and under pavement conduit are usually installed in one of two ways, either via trenching or via boring.

Trenching

When trenching is used, the ground or pavement that is disturbed must be restored (as close as possible) to its original condition. When a road crossing is involved, the installation of conduit via trenching will require the temporary closure of the various travel lanes and reconstruction of the pavement.

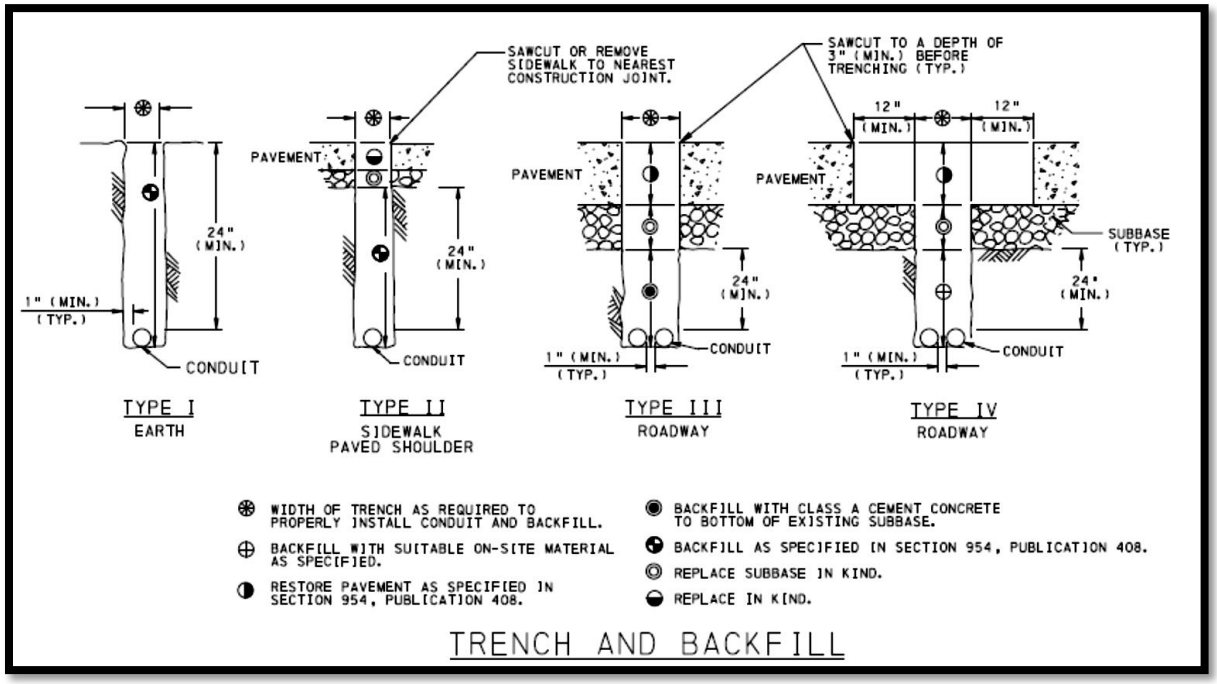
Exhibit 5-23 is a picture of trenching in pavement. **Exhibit 5-21** (left picture) shows a trench in the ground. **Exhibit 5-24** shows information from Publication 408, TC-8804 Sheet 2 of 2.

Boring

Using a boring technique allows all lanes to remain open since the conduit is inserted under the roadway. However, use of traditional jack-and-bore technology requires that a rather large hole be dug on one side of the road to accommodate the jacking machine.

Exhibit 5-23 Trenching in Pavement

Exhibit 5-24 Publication 148, TC-8804 Information for Trench and Backfill

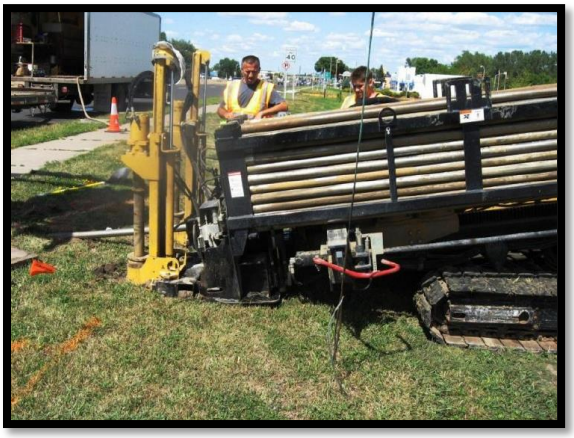


Boring

Using a boring technique allows all lanes to remain open since the conduit is inserted under the roadway. However, use of traditional jack-and-bore technology requires that a rather large hole be dug on one side of the road to accommodate the jacking machine. Publication 408, Section 954.3(b) indicates:

(b) Directional Boring. Install and maintain all erosion and sediment pollution control measures, as indicated on plans, before the start of directional boring. The depth of directional borings should be below the existing roadway subgrade. Do not deform the pavement. Guide the boring. Pneumatic hammers are not allowed. Keep boring pits at least 2 feet from the edge of pavement unless otherwise authorized in writing. Do not use water or drilling fluids to the extent that the pavement might be undermined or subgrade softened. Maintain drilling fluid in bore hole to increase stability of the surrounding soil. Angle the entry/exit holes so that the curvature of the entry/exit holes does not exceed the allowable bending radius of the traffic signal conduit. Cover the boring pits with adequate planking if the drilling operation must be left overnight. Refill and compact boring as specified in Section 206.3(b).

Exhibit 5-25 Direction Boring of Conduit



5.9.9 Depth of Conduit Burial

Conduit should be buried to the proper underground depth as indicated in Publication 148, TC-8804 (see **Exhibit 5-24**), and Publication 408 Specifications or per National Electric Code (NEC) regulations. Typical minimum depth requirement for conduit is 2'-3', with conduit under roadways being installed deeper than conduit underground. However, in order to avoid underground utilities, it may be necessary to vary the burial depth of the conduit – and it is considered acceptable to do so.

5.9.10 Backfilling

Proper backfilling techniques should be used when filling in the conduit trench (see **Exhibit 5-24**). The backfill material should be free of rocks and other angular objects that could damage the conduit. To keep the backfill from settling over time, the backfill material should be applied in layers with each layer being appropriately tamped. This is especially important when installing conduit under pavement to prevent pavement failure associated with settlement of the trench. Refer to Publication 148, TC-8804 for information and the example shown in **Exhibit 5-24**.

5.9.11 Conduit Size and Type

The type of conduit to be used and its diameter is identified in the plans or specifications. For traffic signal work, from 2" to 4" diameter PVC (Poly Vinyl Chloride) conduit is routinely used in underground applications, while 1" to 2" diameter RGSC (Rigid Galvanized Steel Conduit) is frequently used in above ground applications.

5.9.12 Use of Large Diameter PVC Conduits

In a traffic signal installation, the controller cabinet is the focal point for the various cable runs. In other words, all signal, loop, power, and communication cables must eventually reach the cabinet. This results in a large concentration of cables near the cabinet, necessitating the use of larger 3" or 4" diameter conduits or the use of multiple conduits running parallel to one another.

5.9.13 Installing Spare Conduits

If spare conduits are to prove useful in the future, they should be properly installed. Spare conduits should be capped on both ends to avoid water, rodent, or insect intrusion and a pull wire should be inserted so that future cable runs can be easily installed. The location of spare conduits should also be clearly indicated on the as-built plans.

5.9.14 Deterioration of Spare Conduits

Even when spare conduits are correctly installed and their location properly documented, their continuity tends to deteriorate over the years. When attempting to install cable in these conduits, it is not uncommon to encounter breaks in the conduit. These breaks are usually caused by road construction or utility maintenance activities.

5.9.15 Testing Spare Conduits

If existing spare conduit is to be used for a signal project, time should be spent verifying that the conduit run is in usable condition. This can be done by using an air compressor to blow a pull line through the conduit from one junction box to the next. If the line does not make it all the way through, then a break (or obstruction) exists in the conduit run.

5.9.16 PVC Conduit Wall Strength

Two strengths of PVC conduit are routinely encountered in traffic signal work, Schedule 40 and Schedule 80. Schedule 80, the stronger of the two, is usually reserved for conduit runs under roadways where additional conduit wall strength may be needed to keep the conduit from breaking from the weight of heavy vehicles.

5.9.17 Cutting PVC Pipe

PVC conduits typically come in 10' lengths. If a shorter piece of conduit is needed for a particular situation, the conduit should be cut with a special tool designed to cut through PVC pipe. This tool will do the job quickly and does not leave sharp edges.

5.9.18 Assembling PVC Conduit

Lengths of PVC conduit are joined together using PVC couplings and PVC cement. To form a connection, cement is applied to the end of the conduit and the inside of the coupling and then the conduit is inserted into the coupling and allowed to dry, which it does in seconds. Some agencies use a special primer to prepare the surface of the conduit before the cement is applied. Care must be taken that the conduit is shoved all the way into the coupling or a weak point will develop. Also, enough cement must be used to ensure a good seal.

5.9.19 Underground Warning Tape

When installing underground conduit, it is a good idea to bury a warning tape 1' or 2' above the conduit. Then, if in the future, someone digs in the area, they will encounter the warning tape and (hopefully) stop digging before they sever the conduit and the cable which it contains.

5.9.20 Detectable Warning Tape

Some warning tapes have a metal wire imbedded inside them, which allows them to be detected by an above ground monitor so that underground conduits can be located before any digging begins. These "detectable" warning types are frequently used with PVC conduits carrying underground fiber optic cable since neither the PVC conduit nor the fiber optic cable are themselves detectable.

5.9.21 Direct Buried Cable

Cable can be purchased with a special outer jacket that allows it to be buried directly into the ground rather than using conduit. However, such "direct buried cable" is not usually permitted in traffic signal installations.

5.9.22 Cutting Rigid Galvanized Steel Conduit (RGSC)

RGSC conduit also typically comes in 10' lengths. If a shorter piece of conduit is needed for a particular situation, the conduit should be cut with a hacksaw, power saw, or pipe cutter.

5.9.23 De-burring RGSC

Once the conduit is cut, it must be de-burred to remove the sharp edges using a reaming tool or file.

5.9.24 Assembling RGSC

Lengths of RGSC are joined together using couplings that screw together. Teflon tape can be applied to the threads of couplings to ensure water tightness. When the RGSC reaches an end point, such as a controller cabinet or electrical box, special compression connectors and bushings are used to connect the conduit to that item. The use of these items not only keeps the system watertight but their smooth interior surface also ensures that damage will not occur to the cable when pulling it through the RGSC system.

5.9.25 Grounding RGSC

The terminating ends of RGSC should have a ground bushing that can be used to ground the conduit. Grounding RGSC conduit is a safety measure that protects workers and the public should the RGSC conduit somehow become energized by contact with exposed wires.

5.9.26 Attaching RGSC

Conduit straps are used to attach above ground conduit to the structure (bridge, pole, etc.), which carries them. These straps should be spaced close enough to properly support the conduit. The NEC requires that rigid conduit be supported at intervals of no greater than 10', and that the conduit be supported within 3' of each junction box or other enclosure. If it is not feasible to support the conduit within 3' of the enclosure, then this distance can be relaxed to 5'.

5.10 Controller Cabinet Installation

Although smaller controller cabinets can be mounted directly on the signal support pole, the large cabinets required for most modern, multi-phase intersections are too big for pole mounting and must instead be mounted on a separate ground-installed foundation. Exhibit 5-26 shows two pad mounted and one pole mounted controller cabinets.

Exhibit 5-26 Pad Mounted and Pole Mounted Controller Cabinets

Construction specifications for Traffic Signal Controllers are covered in Publication 408, Section 952.3 and are shown below.

952.3 CONSTRUCTION— Sections 953.3 and 1104.01, as shown on the Standard Drawings, and as follows:

(a) Controller Assembly. Install the controller assembly with internal time-base coordination, as indicated. For base-mounted controller assemblies, construct the foundation as specified in Sections 951.3(a) and (b). Connect field wiring for signals, interconnect, and preemption. Connect service to the input/output terminals of the controller assembly. Connect to the equipment safety ground.

When the signal controller becomes operational, and during initial turn-on, demonstrate that all functions are operating in accordance to all the design documents and the applicable standards for the installed unit. Conduct the demonstration, as directed, in the presence of the Representative. Upon successful demonstration that all functions are operating properly the controller will be subject to a 30-day system test. If a fault occurs during the 30-day test period correct the problem and restart the test. Once the 30-day period has expired with no recordable system faults and meets the approval of the Representative the system will be considered for final acceptance.

Connect the conflict monitor or malfunction management unit to function as specified in Section 1104.03(b). When the controller assembly becomes operational, and during initial turn-on, demonstrate that the conflict monitor or malfunction management unit will cause transfer of the signals to flashing operation upon sensing all possible conflicting signal indications. Conduct the demonstration, as directed, in the presence of the Representative. The 30-day system test shall not begin until the conflict monitor or malfunction management unit is functioning properly.

Before or during the initial turn-on, connect output from shutdown relay to the output and power input of the signal load switches. Connect relay to controller assembly to provide flashing operation with the traffic signal controller unit installed or removed. Provide activation of the shutdown relay from any of the following sources:

- Removal of controller voltage, when indicated
- Police panel switch
- Output from conflict monitor or Malfunction Management Unit

Connect systems and communication control equipment as indicated. Before the 30-day system test, field test for the indicated operation as specified in Section 953.3(b).

(b) Time Clock. Install the time clock, when indicated. Connect to input/output terminals of the control equipment. Connect to the equipment safety ground. Field test for indicated operation.

(c) Connector Harness. Provide a separate harness and connector that meets NEMA Standards and is wired for the maximum phase capability of the controller unit.

(d) Cable Connections (NEMA TS-1 & TS-2), Type 170-Advanced Traffic Controller (ATC), and Type 2070-ATC).

1. Copper Cables. Connect the traffic signal cable and interconnection cable to the proper color coded controller terminals as directed by the Representative. Crimp-type connectors are not to be used for traffic control cable or interconnection cable. All wiring and cable connections are to be neat and with all such cables tie-wrapped. Spare conductors of signal cable and interconnection cable are to be neatly wrapped in the cabinet and of the same length as the active conductors. Connect all communication cable conductors to the terminal block. Mount on the inside of the lower left cabinet wall a communication cable terminal block. The terminal block is to have a sufficient

number of connections to splice two 12-pair communication cables together. If applicable, mount on this panel an RS-232 interface for connecting a portable PC to the 170/2070 Microcomputer. The RS-232 interface is to consist of a shielded cable with a DB9 connector at one end, and a 170/2070 C2 type connector at the other. Plug the DB9 connector into the C2 port of the 170/2070 controller.

2. Fiber Optics. Route all fiber optic cables entering the controller cabinet through a 31.75 mm (1 1/4 inch) internal diameter conduit as specified in Section 954. Run a continuous conduit segment from the base of the pole, through the bottom entry hub of the junction box, and into entry hub in the bottom of the Controller Cabinet. Place conduit to maintain the minimum bend radius of fiber

optic cable. The conduit from the cabinet to the closest junction box or manhole is incidental to this item.

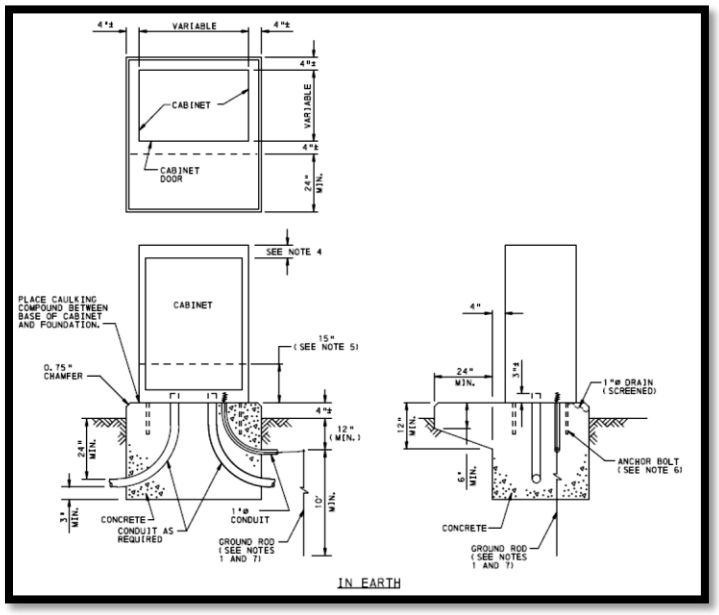
The cabinet is to have the means to hold service loops, each 2.44 m (8 feet) in length, of each of the jacketed fiber optic cables entering and leaving the cabinet. Secure each service loop to the bottom of the lowest rack in the cabinet in such a way as to ensure the minimum bend radius of the cable(s), and prevent interference of any kind. However, the service loops are to be easily removed and reattached during fiber maintenance. Carefully route the fiber optic cable(s) to the patch panel for termination.

The cabinet is to have a patch panel, mounted on an easily removable aluminum panel, to house all internal fiber splices; mount the aluminum panel in an appropriate location inside the cabinet. Secure the fiber optic cable(s) to the panel before entering the patch panel. Terminate all field fibers in the cabinet. If applicable, mount on this panel an RS-232 interface for connecting a portable computer to the 170/2070 microcomputer. The RS-232 interface is to consist of a shielded cable with DB9 connect at one end, and a 170/2070 C2 type connector at the other. Mount the DB9 connector on the panel for easy access, and the C2 type connector plugged into the C2 port of the 170/2070 controller.

5.10.1 Controller Cabinet Foundation

Installation of the controller cabinet assembly begins with construction of the controller cabinet foundation. Forms are placed and concrete is poured in order to construct a stable, elevated base to which the cabinet can be attached. A concrete pad is often installed in front of the cabinet foundation to provide a stable, dry place to stand for anyone working inside the cabinet.

Exhibit 5-27 Publication 148, TC-8802 Controller Assembly Standard Drawing



5.10.2 Cabinet Anchor Bolts

A number of anchor bolts, usually four, are embedded in the concrete while it is still wet. These bolts are used to attach the cabinet to the foundation. To give the foundation and anchor bolts time to achieve sufficient support strength, a curing period of no less than two days should be observed before attaching the cabinet. The bolt pattern must be obtained from the cabinet supplier prior to installation of bolts.

5.10.3 Cabinet Conduits

Before pouring the concrete, all of the conduits that will enter the cabinet through the foundation must be placed, including the conduit for the grounding wire and any spare conduits. The end of the conduits should protrude about 2" above the top of the foundation so that the conduit does not serve as a catchall for dirt and debris (see **Exhibit 5-28** for a picture of conduit in a cabinet foundation).

Exhibit 5-28 Cabinet Conduits

5.10.4 Do Not Embed Grounding Electrodes

It is not considered good practice to embed grounding electrodes directly in the controller foundation since the chemical reaction between the concrete and the copper rods can lead to corrosion. If grounding electrodes are placed in the foundation, they should first be inserted into a PVC sleeve.

5.10.5 Plug Conduits

All conduits entering the cabinet may be plugged to protect against water intrusions, rodent entry, and insect infestations. This is done by inserting duct seal into the conduit and forming it around the wires. In addition, all spare conduits should be capped.

5.10.6 Silicone Seal

After the concrete has cured, the cabinet can be attached to the anchor bolts. A silicone sealant is typically applied between the bottom of the cabinet and the foundation to form a watertight seal between the cabinet and the concrete foundation.

5.10.7 Attaching the Controller Cabinet

The controller cabinet usually comes completely configured from the factory. After bolting it to the concrete foundation (see **Exhibit 5-29**), connect the field wiring to the field terminals (see **Exhibit 5-30**), hook-up the power wires (see **Exhibit 5-31**), and attach the controller, conflict monitor, and detector units.

Exhibit 5-29 Cabinet Bolted to Foundation

Exhibit 5-30 Cabinet Terminal Hook-ups

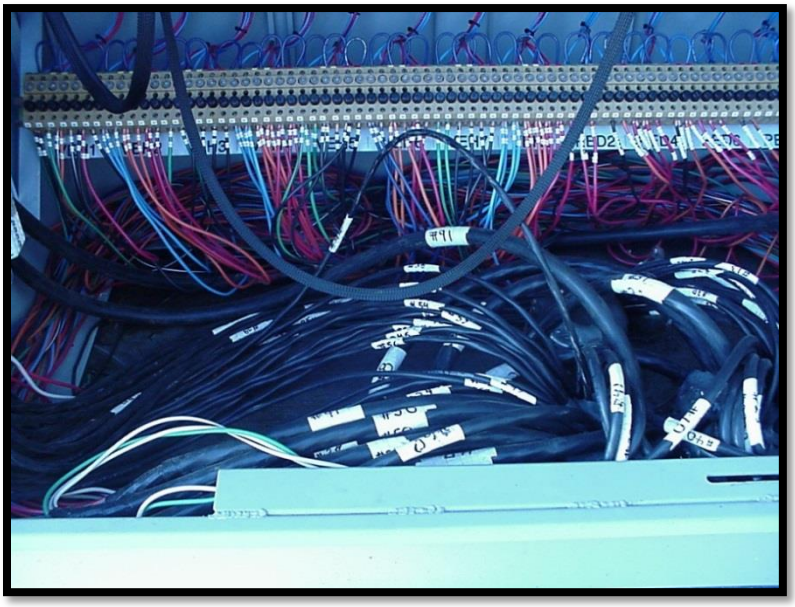
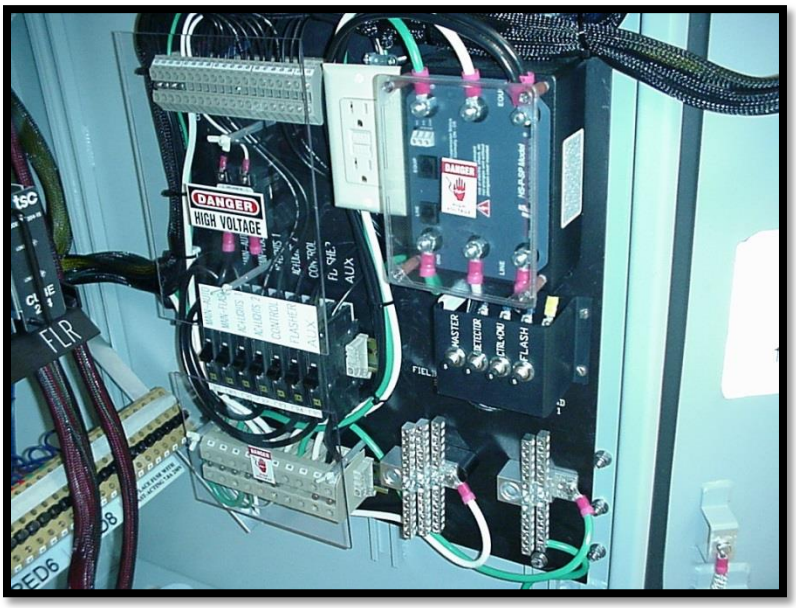


Exhibit 5-31 Power Hook-ups



5.10.8 Adding Conduits to Existing Cabinets

If no spare conduits are available, the need may arise to add a conduit to an existing controller cabinet. This can be done in one of two ways:

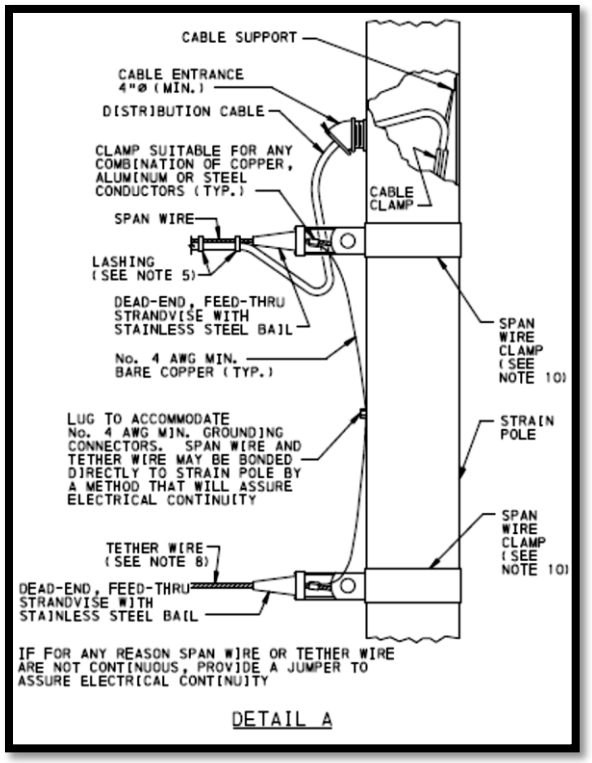
A. Drilling through the concrete foundation on an angle and installing PVC conduit, or
B. Drilling a hole in the side of the cabinet and adding a section of RGSC

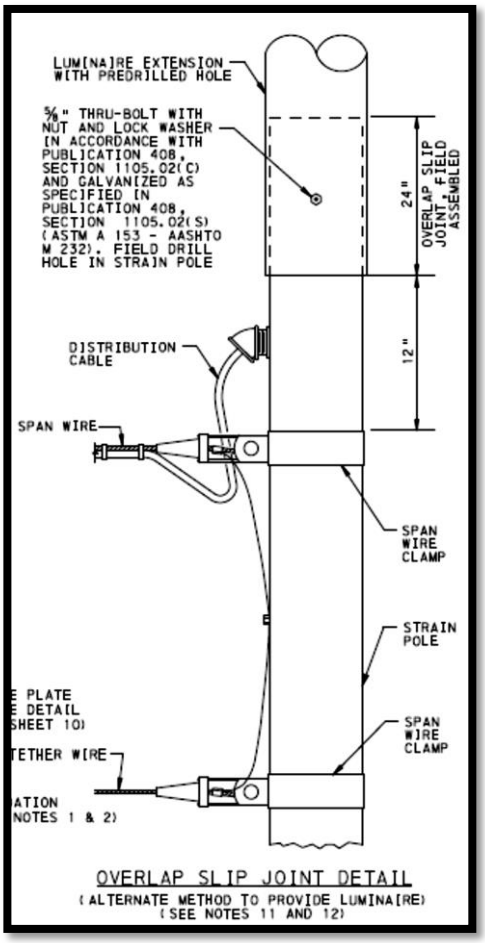
5.11 Stain Pole Wire Installations

Typically, two wire installations are used for strain poles. Refer to **Exhibit 5-18** for a sample of Publication 148, TC-8801.

The top wire (span wire) provides structural support and carries the signal cable that is attached to it. The bottom wire (called tether wire) provides structural support. Refer to **Exhibit 5-32** for additional information on Publication 148, TC-8801 regarding strain pole details.

Exhibit 5-32 Publication 148 Stain Pole Details, TC-8801





5. LASH DISTRIBUTION CABLE TO THE SPAN WIRE WITH PREFORMED GALVANIZED STEEL RODS, SELF-LOCKING CABLE TIES OF THE OUTDOOR TYPE, SOLID COPPER WIRE, GALVANIZED STEEL WIRE, STAINLESS STEEL WIRE, OR CABLE RINGS AND SADDLES. MAKE ONE COMPLETE WRAP WITH WIRE LASHING AT INTERVALS NOT EXCEEDING 6". SECURE ENDS OF WIRE LASHING TO THE SPAN WIRE WITH AN ALL PURPOSE SPLIT BOLT CONNECTOR. PLACE CABLE TIES AT INTERVALS NOT EXCEEDING 12". PROVIDE PROPER SIZE AND SPACING OF CABLE RINGS AND SADDLES ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.

8. TETHER WIRE - ¼" DIAMETER (NOMINAL) WITH A BREAKING STRENGTH OF 1900 lbs MEETING ASTM A 475, CLASS A, COMMON GRADE.

5.11.1 Diameter of Signal Support Wires

The required diameter of the signal wires depends on the loads to be carried, with larger diameter wire being used for heavier loads. Care must be taken to ensure that the wire size called for in the plans and specifications is used. 3/8" or 7/16" diameter high-strength steel cable is typically used for span wire installations.

5.11.2 Pole Attachment Hardware

The span wires are used secured to the support pole with attachment hardware that varies by type of pole (wood or steel). Refer to **Exhibit 5-32** for from Publication 148, TC-8801 regarding strain pole attachment hardware.

5.11.3 Strandvice

A strandvice (also called an "automatic compression dead-end clamp") works like a "Chinese finger" in that it allows the span wire to be pulled through it in only one direction. The round end of the strand vice is passed through the eyebolt and then connected to the end of the vice that looks like a funnel. The span wire is then pushed through the funnel.

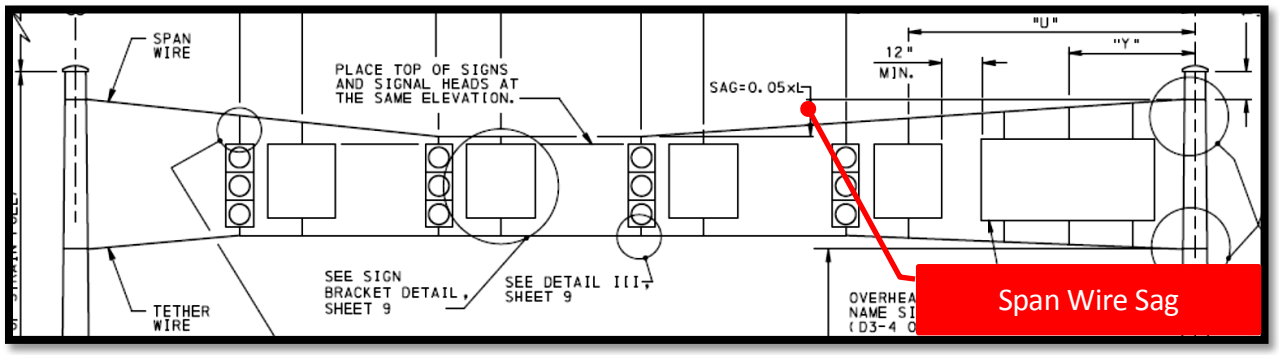
5.11.4 Chain Hoist

Since the final strain on the span wire will be substantial, a chain hoist (also known as a coffin hoist, a come-along, or a hand winch) must be used to pull the span wire through the strand vice once a load is placed upon it.

5.11.5 Tensioning the Span Wires

Once the span wire hangers and signal heads have been attached to the pole, the chain hoist can be used to tighten the span wires until the appropriate amount of span wire sag is obtained. Refer to Publication 148, TC-8801 sheet 2 of 10 for information on span wire sag. **Exhibit 5-33** is a portion of TC-8801 regarding span wire sag.

Exhibit 5-33 Publication 148, TC-8801 Span Wire Sag Example



5.11.6 Release Switch

If a lessening of the span wire tension is desired, a release switch can be depressed with a flat end screwdriver that allows the span wire to go in the opposite direction through the strand vice. Care must be taken that the chain hoist is in place and tensioned to prevent the span wire from falling and causing injury.

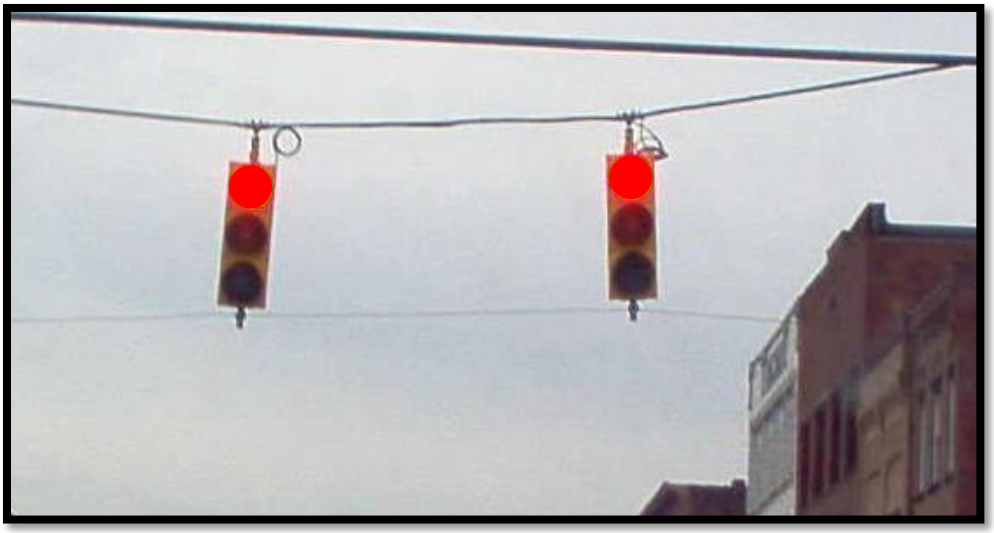
5.11.7 Fiberglass Insulators

When a span wire comes within 6' of an overhead electric line, some agencies will install a fiberglass insulator in the span to reduce the potential for conductivity between the electric line and the span wire. The fiberglass insulator does not fit over the span wire, but is actually a special section that replaces the steel span wire for a certain distance. Therefore, if a fiberglass insulator is used, it should have a breaking strength that is at least as great as the span wire itself.

5.11.8 Installing Signal Heads on Span Wires

After the span wire has been appropriately tightened, the weighted hangers are replaced with the signal head assemblies. Exhibit 5-34 is an example of signal heads on a span wire installation.

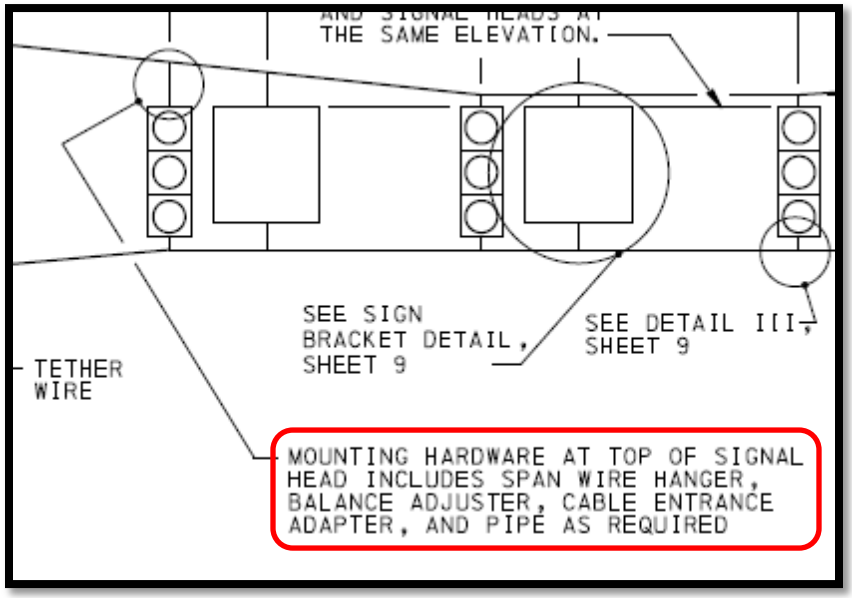
Exhibit 5-34 Signal Heads on Span Wire



Extension Hanger

If two span wires support signal heads, then each head is attached to the wires via an adjustable extension hanger. Small diameter steel pipes, referred to as "pipe hangers," are sometimes used instead of extension hangers to attach the disconnect hanger to the wires. Exhibit 5-35 is a portion of TC-8801 regarding span wire to signal head mounting hardware.

Exhibit 5-35 Publication 148, TC-8801 Span Wire Mounting Hardware



Extension Hanger Connections

The extension hanger is connected to the bottom (tether) wire using a disconnect cable clamp and to the top (span) wire using a span wire clamp (also known as a "saddle clamp" because of its distinctive saddle shape).

Disconnect Hanger

Instead of wiring the signal heads directly to the signal cable that runs to the controller, some agencies prefer to use an intervening disconnect hanger. The disconnect is wired to the signal cable and the signal head then "plugs" into the disconnect. The use of a disconnect hanger allows signal heads to be easily and quickly removed or changed.

Tri-stud Connector

The extension hanger is connected to either the signal head or the disconnect hanger using a tri-stud connector. However, when a pipe hanger is used, the top of the signal head or disconnect hanger is threaded and the pipe hanger screws into it.

Balance Adjuster

A balance adjuster can be added to the signal head assembly to allow the vertical alignment of the signal head to be adjusted.

5.12 Installing Signal Heads on Mast Arms

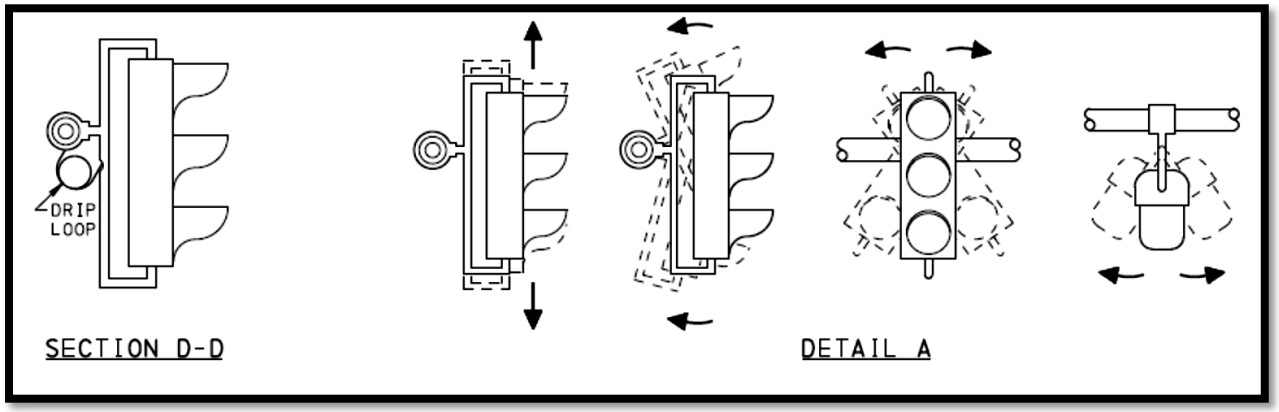
As with span wires, there is more than one way to attach a signal to a mast arm. These include:

A. Free-Swinging Mast Arm Hangers
B. Disconnect Hangers
C. Rigid Brackets
D. Slip-Fitters

Exhibit 5-36 shows pictures of traffic signal head bracketing. **Exhibit 5-37** is a portion of Publication 148, TC-8801 regarding signal head bracketing. The standard specifications are found in Section 955 and 1104 of Publication 408.

Exhibit 5-36 Traffic Signal Head Bracket System

Exhibit 5-37 Publication 148, TC-8801 Mast Arm Signal Head Mounting Hardware



Section 955.3(a) of Publication 408, Standard Specification states the following:

(a) General. Securely mount signal heads, using signal mounting brackets, where indicated, and according to the regulations. Install signal heads over roadways with the top of the housings at the same elevation and as shown on the Standard Drawings. Where vehicular and pedestrian signals are to be installed on the same support, separate the assemblies. Aim vehicular signal heads, as directed, toward a point approximately 45 m (150 feet) in advance of the stop line and in the center of the traveled traffic approach. Aim pedestrian signals to the far side of the crosswalk they are to control. Securely cover signals with an opaque material that covers and hides signal indicators from the view of traffic until the signal is put into operation. Use material that is sufficiently opaque to hide any lighted signal face indication. Burlap may be used as a hood material if the signal indications are not lighted and will not be until the hood is removed. Maintain the hood and replace or repair the hood if it becomes loose, torn, or removed.

5.12.1 Free-swinging and Disconnect Hangers

A signal head can be suspended below the mast arm using either a free-swinging hanger or a disconnect hanger. As with span wire mounted heads, a balance adjuster can be added to the signal head assembly to allow the vertical alignment to be adjusted.

5.12.2 Rigid Attachments

A signal head can be rigidly attached to the mast arm using either a rigid bracket or a slip-fitter. Rigid brackets are often referred to by their trade name. These brackets, which are banded to the mast arm, are very versatile - allowing the signal head to be situated in almost any position.

5.12.3 Slip-fitter

As its name implies, one end of the slip-fitter bracket “slips” over the end of the mast arm, supporting the signal head in either a top mount or side mount configuration. The signal cable passes through the slip-fitter and into the head.

5.12.4 Degree Top Mount Slip Fitter

In the top mount configuration, the other end of the slip-fitter bracket attaches to the top of the signal head. The term “cushion hanger” is used to refer to this type of mounting arrangement.

5.12.5 Elevator Plumbizer

In the side mount configuration, the other end of the bracket is situated between the signal sections. When used in the side mount configurations, the slip-fitter is known as an “elevator plumbizer.”

5.12.6 Rubber Grommet

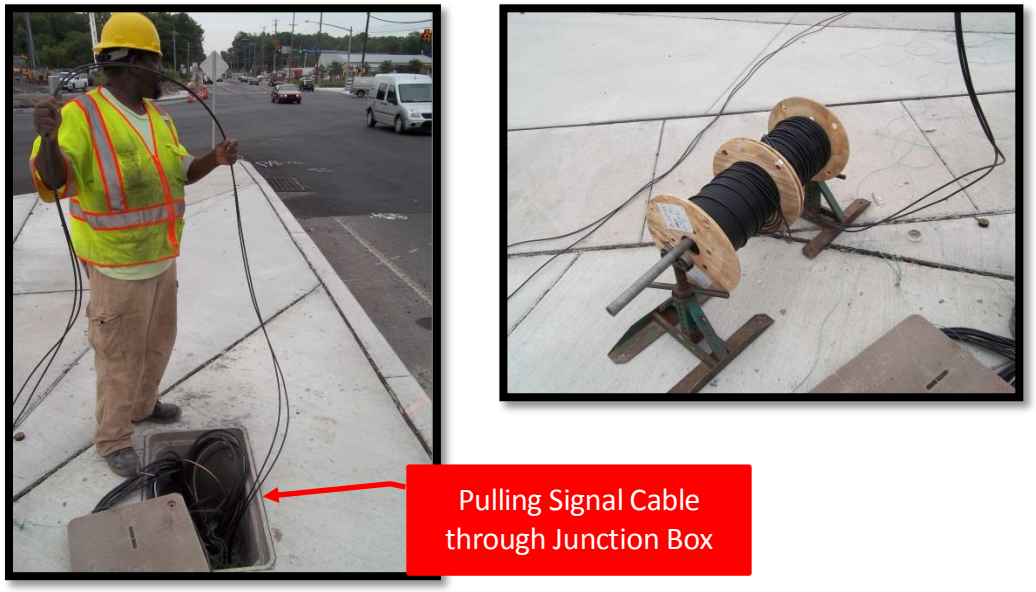
A hole must be drilled in the mast arm at every signal head location so that the signal cable can reach the signal head. Regardless of whether this hole is factory drilled or field drilled, a rubber grommet should be installed in the hole to keep the signal wire from chaffing on the sharp edge of the hole.

The following discussion of overhead wiring assumes the use of disconnects. When disconnects are not used, the wiring technique is slightly different.

5.13 Signal Cable Installation

Signal cable must be installed between the controller and each vehicular or pedestrian signal head. Although the number and size of the conductors in a signal cable can vary, from 3 to 16 conductors of size AWG #12 or #14 is typical. Exhibit 5-38 shows signal cable installation through a junction box.

Exhibit 5-38 Signal Cable Installation



Publication 408, Section 954.3(e)1 regarding signal and cable wire construction is as follows:

(e) Signal Cable and Wire.

1. General. Install indicated cable to form a continuous circuit between the proper equipment terminals. Install cables inside supports and brackets.

Insert cable in conduit using lubricant. If new cable is to be installed in conduit with existing conductors, remove the existing cable, clean the conduit, as specified in Section 910.3(g), and then

insert both old and new cable into the conduit as a unit. Replace existing cable damaged during removal as directed.

Use insulated, locking, spade terminals for conductor terminations. Neatly arrange conductors and tie with cable ties within fixtures. Attach cable tags at splices, indicating phase and function, within all junction boxes, pole bases, and cabinets.

Terminate all spare signal conductors collectively with a pressure-type mechanical lug and cover with electrical tape. Ground spare conductors.

Attach conductor terminations in controller cabinets to barrier-type terminal blocks with no more than one conductor per screw, otherwise use pressure-type mechanical lugs to accommodate the number of conductors being terminated. Identify and mark blocks.

Terminate on grounding bus and identify spare and reserved conductors.

Provide enough slack cable in pole bases, controller cabinets, and junction boxes to allow for proper wiring connections. For pole mounted signals and pedestrian pushbuttons, install signal cable inside pole to the terminal block of the signal or pushbutton.

For span wire installations, lash cable to the span wire, or secure using cable rings and saddles.

Provide drip loops at wire entrances to poles and signal heads. Secure drip loops with outdoor-type, self-locking cable ties.

5.13.1 Wiring the Heads

The wires of the signal head harness are connected to the terminal strip (see **Exhibit 5-39**) inside the signal head so that the correct indication is displayed. Cable runs from the signal heads to the handhole where they are spliced and run through the conduit system to the controller.

Installing Neutral Wires

The neutral (or return) wires are connected to the same terminal.

Neutrals for Multiple Heads

If the disconnect serves more than one signal head, then a jumper wire must be used to connect the neutral terminals of the various heads.

Exhibit 5-39 Signal Head Terminal Strip

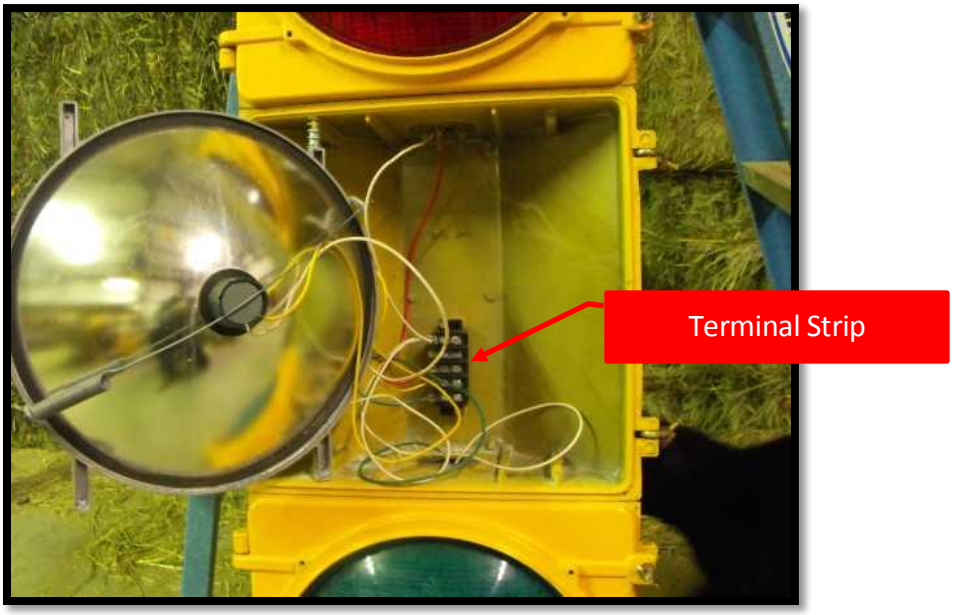
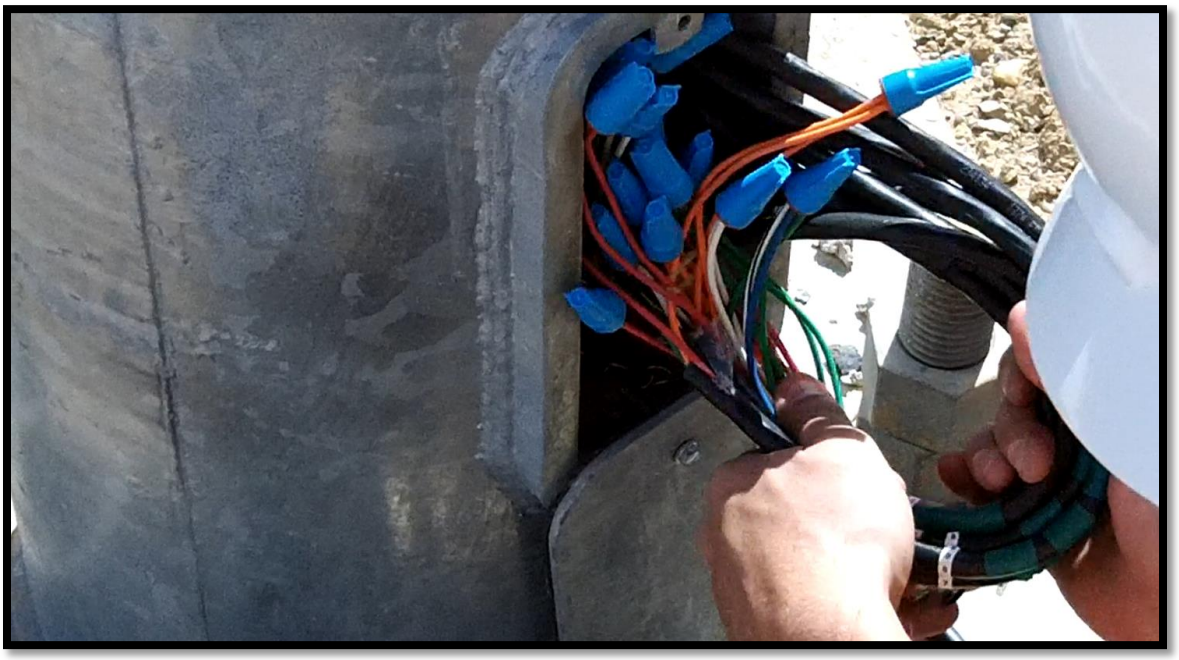


Exhibit 5-40 Connections in Handhole



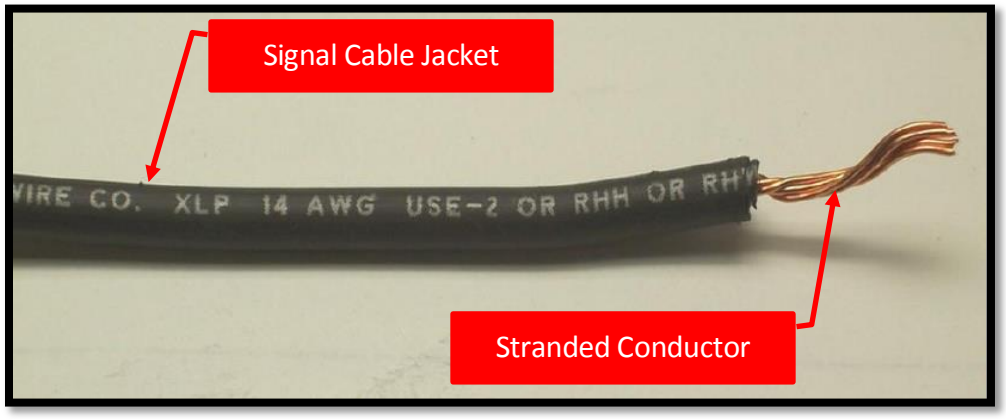
5.13.2 Signal Cable Jacket

The outer jacket of the signal cable (see **Exhibit 5-41**) should meet IMSA Specification 20 for Polyethylene jacketed signal cable, or 19 for Polyvinyl Chloride jacketed signal cable.

5.13.3 Stranded Conductors

Although solid copper conductors are easier to splice and terminate, stranded copper conductors (see **Exhibit 5-41**) are more flexible. The flexibility is important when working within the relatively tight confines of disconnects, poles, and cabinets. Therefore, most technicians prefer stranded conductors.

Exhibit 5-41 Stranded Conductor



5.13.4 Required Number of Spares

Although some agencies specify the exact number and size of the conductors to use in each cable, other agencies give the contractor some flexibility in making these decisions. In either case, a sufficient number of spare conductors should be provided so that any conductors that are damaged can be replaced, and to accommodate additional signal heads that might be required in the future.

5.13.5 Terminating Spare Conductors

At the signal head end, all spare conductors should be terminated, capped, or taped-off. Leaving wire ends exposed is a dangerous practice since exposed wires can shock workers if they somehow become energized. At the controller end, all spare conductors should be terminated on the controller ground bussbar. Spare conductors should be identified as such in the controller cabinet.

5.13.6 Color Codes

Most agencies have a standard color-code scheme for the wire to be used in the various signal circuits. For PennDOT, this is in Publication 408, Section 954.3(e)2 regarding conductor color codes as follows:

2. Conductor Color Codes.

2.a Pedestrian Pushbutton.

Cable	1 Black	—Spare*
	2 White	—Logic Ground
	3 Red	—Pedestrian Call Detector

2.b Pedestrian Signal.

5/C Cable	1 Black	—Walking Person (Walk)
	2 White	—Neutral
	3 Red	—Upraised Hand (Don't Walk)
	4 Green	—Reserved
	5 Orange	—Spare*
7/C Cable	1 Black	—Walking Person (Walk)
	2 White	—Neutral 1 and 2
	3 Red	—Upraised Hand (Don't Walk 1)
	4 Green	—Reserved
	5 Orange	—Walking Person (Walk 2)
	6 Blue	—Upraised Hand (Don't Walk 2)
	7 White/Tracer	—Spare*

2.c Vehicular Signal.

5/C Cable	1 Black	—Green Ball/Arrow
	2 White	—Neutral
	3 Red	—Red Ball
	4 Green	—Reserved
	5 Orange	—Yellow Ball/Arrow
7/C Cable	1 Black	—Green Ball
	2 White	—Neutral
	3 Red	—Red Ball
	4 Green	—Reserved
	5 Orange	—Yellow Ball
	6 Blue	—Green Arrow
	7 White/Tracer	—Yellow Arrow/Spare*

5.13.7 Attaching Cables to Span Wire

Signal cable is attached to the messenger wire using several methods, such as pre-formed lashing rods, cable rings, or cable ties (tie wraps). Some agencies do not permit the use of the cable ties since they tend to weaken over time. If cable ties are used, they should be made of material that does not deteriorate under the sun's ultraviolet radiation.

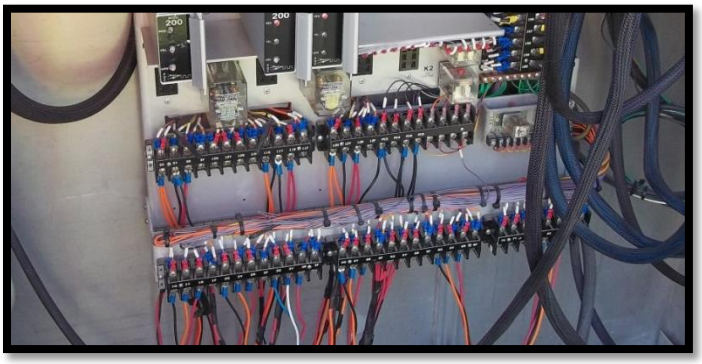
5.13.8 Pulling Signal Cable

The key in pulling signal cable is to not damage the conductors or scrape-off insulation during installation. Care must be taken not to "force" the cable or to drag it across any sharp surfaces. A little patience and thoughtful consideration during cable installation will produce a quality installation.

5.13.9 Terminating the Signal Conductors in the Cabinet

Each conductor in the signal cable must be attached to the appropriate field terminal within the controller cabinet (see **Exhibit 5-42**). There is usually a connection chart or blueprint inside the cabinet that specifies which terminals control which phases and indications. For example, the chart might indicate that terminal 135 controls the phase 4 green indication.

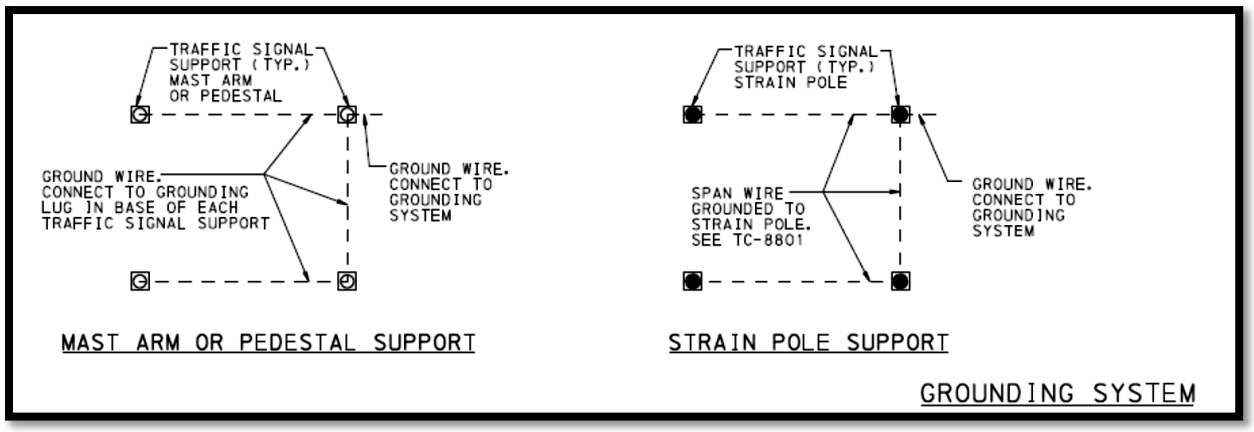
Exhibit 5-42 Controller Cabinet Terminal Block



5.14 Signal System Grounding

Making sure that all the metallic components of a traffic signal system are effectively grounded helps protect the public, signal technicians, and electronic equipment from injury or damage due to unanticipated voltage transients, such as those caused by nearby lightning strikes. If these components are not effectively grounded, then a much greater potential exists for harmful electric current to travel a path that goes through a person or a piece of equipment. Electricity seeks the path of least resistance and a lack of an effective ground or a proper grounded conductor could make you part of that path.

Exhibit 5-43 Publication 148, TC-8804 – Grounding System



5.14.1 Installing Grounding Electrodes

Grounding electrodes are usually about 10’ in length, 5/8” in diameter, and made of steel for strength but clad in copper to increase conductivity and decrease corrosion. In a signal system, grounding is achieved by driving these electrodes into the earth and then attaching the metallic portions of the signal system to them using grounding conductors (see Section 4.7). Sufficient electrodes should be installed so that the resistance-to-ground of the system is less than 25 ohms.

5.14.2 Connecting Grounding Electrodes

Since more than one grounding electrode may be needed to meet the 25 ohms criterion, the electrodes can be fastened together end-to-end using advanced couplings and driven further into the ground until the required conductivity is obtained. Follow NEC regulations to determine the proper arrangement. TC-8804 of Publication 148 includes Note 3 shown below:

5.14.3 Grounding Electrode Array

An alternative means of meeting the 25-ohm criterion is to drive a series of grounding electrodes to the same depth and then connect them together with copper wire to form an electrode array. In an array, electrical standards require that the individual rods be spaced at least 6’ apart.

5.14.4 Pole-Grounded Effectively

To provide a grounding conductor for equipment, the metallic portions of pedestals, mast arms, junction box lids, and strain poles are wired to grounding electrodes that are buried in the earth. Span wires are also typically tied to this grounding system and for concrete strain poles, the pole reinforcing is tied-in as well.

5.14.5 Controller-Cabinet Grounded Effectively

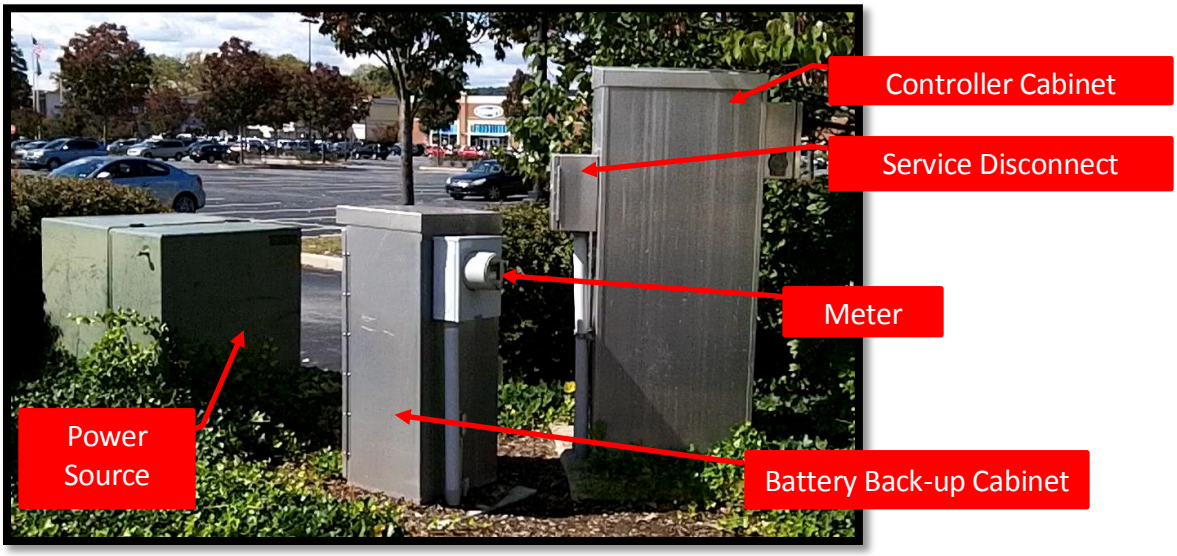
The controller cabinet should also be grounded effectively. However, the pole grounding system should not be connected to the controller cabinet grounding system. Keeping the two grounding systems separate makes it more difficult for voltage transients caused by lightning strikes to travel down the pole and into the cabinet.

(It should be noted that some agencies prefer to connect the pole and cabinet grounding systems together to avoid potential voltage differences between the two systems.)

5.15 Electric Power Service Installation

Electric power service may be provided by either an overhead or underground connection. Although underground installations are more aesthetically pleasing since the service wire is hidden from view, they are also more expensive. Exhibit 5-44 is an example of an electrical power service arrangement.

Exhibit 5-44 Electrical Power Service



5.15.1 Check with Local Electric Company

Many local electric companies have special requirements for electric power service installations. Some require a permit and associated connection fee while some do not. Some require that a certified electrician "pull the permit" while others do not. And, some require the installation of a meter to record the amount of electricity used by the signal, while others charge the owner a flat rate. Consequently, the local electric company must be contracted and this information obtained before the construction begins.

5.15.2 Overhead Power Service Connection

In an overhead connection, the service cable from the power source enters a weatherhead at the top of the service pole, travels down the pole inside Rigid Galvanized Steel Conduit (RGSC) to a meter base (if one is required) and then on to a disconnect breaker that provides over-current protection. From there, the cable travels down the remainder of the service pole in RGSC and then underground in PVC conduit until it enters the controller cabinet through the foundation. The power wires are attached to the appropriate terminals on the cabinet's power panel.

5.15.3 Underground Power Service Connection

In an underground connection, the service cable from the power company arrives at the service pole in an underground conduit and travels up the service pole in RGSC to the line side of the meter base and disconnect. The cable leaves the load side of the disconnect and travels back down the service pole in RGSC, then underground in PVC conduit to the power panel located inside controller cabinet.

5.15.4 Size of the Service Wire

The NEC requires that the minimum service wire be AWG #8 or larger. This is determined by service main disconnect size.

5.15.5 Size of the Circuit Breaker

The circuit breaker for the electrical disconnect should be rated above that of the circuit breakers located within the cabinet so that the cabinet circuit breakers trip first. Typical values would be 30 amps for the main cabinet circuit breaker (which handles the heads, the controller, and the conflict monitor) and 15 amps for the auxiliary circuit breaker (which handles the power vent, cabinet light and duplex receptacle). Fifty amps could be a typical value for the electric power service circuit breaker.

5.15.6 Grounding the Power Service

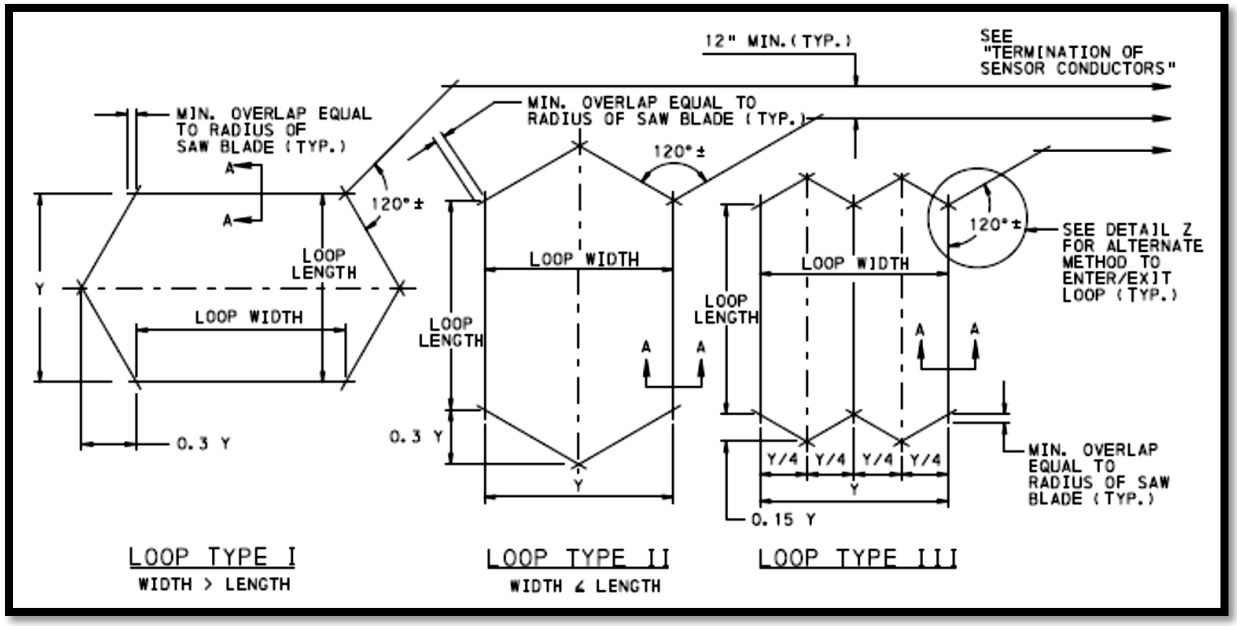
The electric power service assembly, including the disconnect, meter base, and associated RGSC, must be connected to the grounding system of the pole on which the power service assembly is attached.

5.16 Inductance Loop Installation

Although many types of vehicle detection systems exist (video, magnetometers, microwave, infrared, etc.), inductance loops are the most common. Therefore, the installation of inductance loops and detector units is discussed here. **Exhibit 5-45** is a picture of a saw-cut inductive loop detector. Exhibit 5-46 is a portion of TC-8806, saw-cut loop detector detail.

Exhibit 5-45 Inductive, Saw-Cut Loop Detector

Exhibit 5-46 Inductive, Saw-Cut Loop Detector detail from Publication 148, TC-8806



Publication 408, Section 956.3(a) regarding Loop Detector construction states:

956.3 CONSTRUCTION—Section 950.3, as shown on the Standard Drawings, and as follows:

(a) Loop Detector. Saw cut slots in the pavement for the sensor, as indicated. Rotary drill a hole for the conduit at curb. Blow the slot and hole free of moisture and debris. Install the conduit. Install the number of sensor turns to obtain the inductance required by the manufacturer to achieve proper operation, without splices, kinks, or curls, and without straining or stretching around the corners of the slot. Install a minimum of two turns of wire for each loop detector. Use a blunt nonmetallic tool to seat the sensor in the bottom of the slot. Check for slack, raised portions, and tightness. Correct if necessary. Insert the two leads from the loop, twisted together a minimum of 10 turns per meter (3 turns per foot), in the conduit leading to the junction box. Test leakage resistance, series resistance, and inductance before sealing the sawcut slot. Leakage resistance greater than 10 megohms is necessary when tested at 375 V(dc) minimum. Series resistance is not to exceed 2.6 ohms per 300 m (1,000 feet). Inductance is to be between 50 microhenries and 700 microhenries. Seal the conduit with duct seal. Seal the hole and slots with sealant, according to the manufacturer's instructions. Do not apply the sealant if the air temperature is below 7 °C (45F), or during precipitation. Fill the slot to within 3 mm (1/8 inch) of the pavement surface and ensure that there are no voids. Do not allow traffic on the slot until the sealant is cured. Remove excess sealant from adjacent road surfaces, but do not use solvents.

If the contract includes resurfacing in the loop area, install the sensor in the existing pavement structure or in the binder course before placement of the wearing course. Do not install the top course of pavement before the sealant is cured.

Splice the sensor wires to the lead-in cable as shown on the Standard Drawings. Encapsulate the splice with sealant to prevent water from penetrating the splice. Connect the sensor to each lead-in pair, as indicated. Band all excess loop sensor/lead-in cable in the junction box to prevent movement resulting in false calls. Extend the lead-in cable to the terminal strip in the controller cabinet, without splices. Measure inductance of loop and lead-in. Inductance is to be between 50 microhenries and 700 microhenries. Place a record of the inductance readings in the controller cabinet. Connect to the loop detector amplifier. Adjust the amplifier, according to the manufacturer's instructions, to obtain the necessary sensitivity.

5.16.1 Install the Correct Type of Loop

The type, length, and location of the inductance loops to be used at a particular intersection are indicated in the plans. Exhibit 5-47 shows two sample plans with loop detectors. Loops come in a variety of shapes, sizes, and configurations and care must be taken to install the one that the designer has specified. Exhibit 5-48 illustrates some of the detection options as shown in Publication 149, Traffic Signal Design Manual. The location of the loop in relation to the stop line is another important stipulation that must be followed.

Exhibit 5-47 Loop Detectors Example Plans

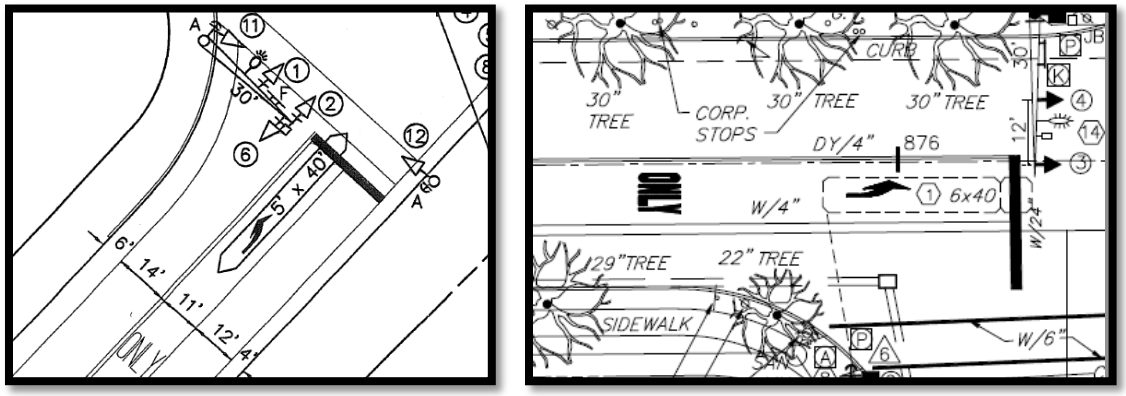
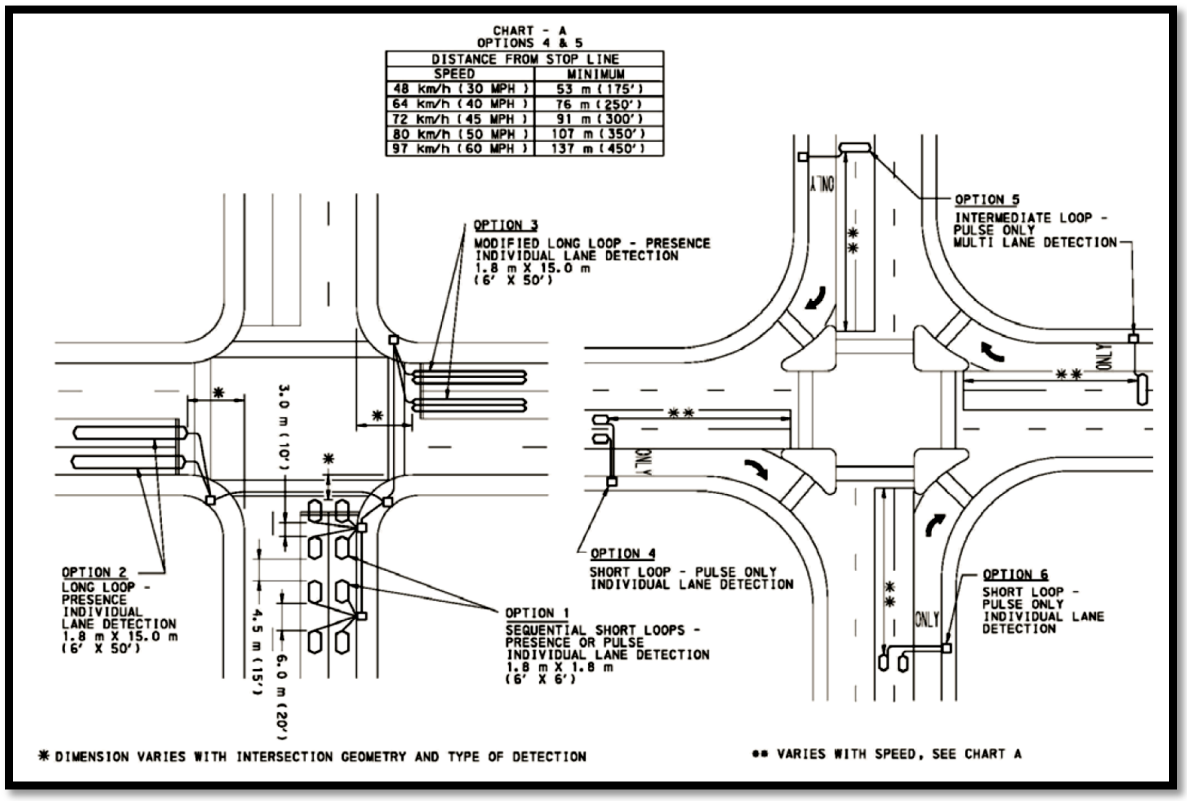


Exhibit 5-48 Detection Options Sample from Publication 149



5.16.2 Under Pavement Loops

When an intersection is being repaved in conjunction with the original installation, the plans sometime call for the inductance loops to be installed before the final surface course is place. This must be recognized and installation coordinated with the paving contractor.

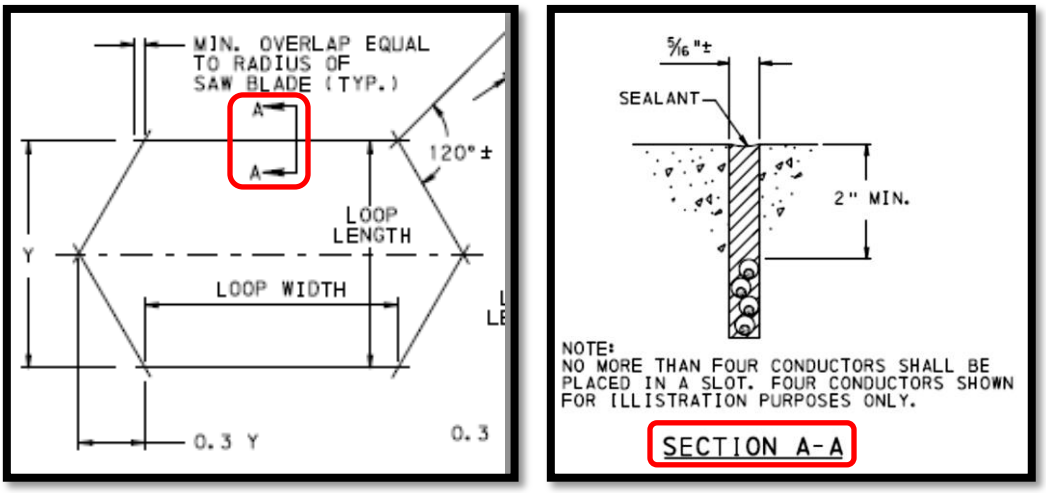
5.16.3 Marking the Loops

An outline of the loops should be made on the pavement with chalk or spray paint prior to cutting the loops. The outline will not only permit the inspector to verify the loop location before cutting the pavement but will also serve as a guide for the person operating the saw.

5.16.4 Saw-cut Depth

The depth of the saw-cut depends on the number of turns of wire and the diameter of the wire. Details on saw-cuts depths are found in Publication 148, TC-8806. An example of TC-8806 is found in Exhibit 5-49. Installing the loop wires in a saw-cut that is too shallow reduces the level of protection from the elements while installing the loop too deep is costly and can result in reduced sensitivity. As shown in the detail, 2" of sealant is the minimum amount from the top of the wire.

Exhibit 5-49 Saw-cut Depth from TC-8806



5.16.5 Protecting Against Insulation Damage

Sharp corners that might damage the loop wire insulation are typically eliminated by either installing an angled saw-cut at the corners of the loop or by installing rounded corners.

5.16.6 Cleaning Out the Saw-cuts

After the saw-cutting operation is complete, the saw-cuts must be cleaned of all loose debris using either a blower or a strong vacuum. If debris is left on the bottom of the saw-cut, then the wires will not be deep enough. Debris could also cause unwanted voids to form when the loop sealant is poured into the saw-cut.

5.16.7 Wire Size

With the saw-cuts cleaned of loose debris, the loop wire is installed in the saw cut. Inductance loops are typically constructed using AWG #14 or AWG #12 wire rated for 600 volts.

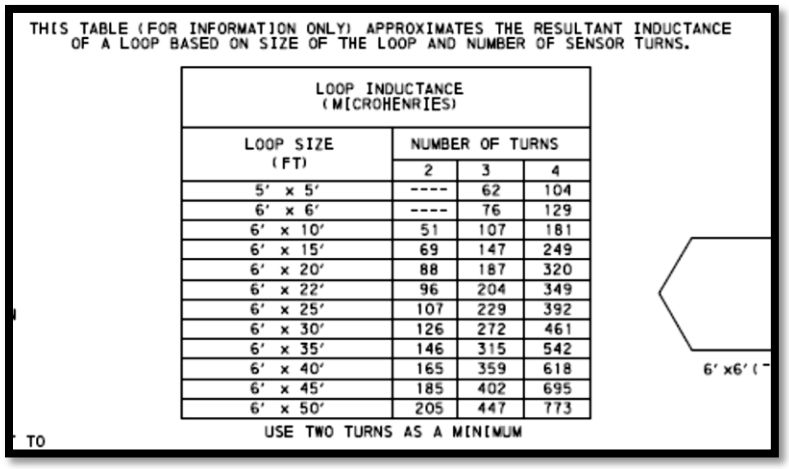
5.16.8 Wire Type

The loop wire should meet IMSA Specifications 51-1 for PVC insulated wire, 51-3 for XHHW cross-linked polyethylene insulated wire, or 51-5 for PVC insulated wire with PVC or a polyethylene tube jacket. Polyethylene insulation is generally preferred over PVC insulation since it is more resistant to mechanical damage from abrasion and since it does a much better job of preventing water seepage. Stranded wire is preferred over solid wire since its mechanical characteristics make it more likely to survive bending and stretching.

5.16.9 Use the Correct Number of Turns

Either the plans or specifications will indicate the number of "turns" of loop wire that must be installed in the saw-cut. The number of "turns" is the number of times that a loop wire is wound around within the saw-cut. See Exhibit 5-50 for information from TC-8806.

Exhibit 5-50 Number of Turns from TC-8806



THIS TABLE (FOR INFORMATION ONLY) APPROXIMATES THE RESULTANT INDUCTANCE OF A LOOP BASED ON SIZE OF THE LOOP AND NUMBER OF SENSOR TURNS.

LOOP SIZE (FT)	LOOP INDUCTANCE (MICROHENRIES) NUMBER OF TURNS		
	2	3	4
5' x 5'	----	62	104
6' x 6'	----	76	129
6' x 10'	51	107	181
6' x 15'	69	147	249
6' x 20'	88	187	320
6' x 22'	96	204	349
6' x 25'	107	229	392
6' x 30'	126	272	461
6' x 35'	146	315	542
6' x 40'	165	359	618
6' x 45'	185	402	695
6' x 50'	205	447	773

USE TWO TURNS AS A MINIMUM

6' x6' (

TO

5.16.10 Backer Rod

After the wire is placed in the saw-cut, short strips of non-metallic hold-down material (such as polyethylene foam) are wedged into the saw-cut at 1' intervals. These strips keep the loop wire from floating towards the surface when loop sealant is poured into the saw-cut.

5.16.11 Avoid Sharp Objects

When installing the loop and hold-down material, sharp objects that could damage the loop wire (such as a screwdriver) should never be used.

5.16.12 Use of Proper Loop Sealants

Loop sealants are specially formulated to encapsulate the loop wires and provide years of protection from water intrusion and physical abrasion. These sealants are designed to remain flexible under a variety of weather conditions, including temperature extremes. Materials that do not have these properties, such as roofing tar or asphalt sealers should never be used to seal inductance loops.

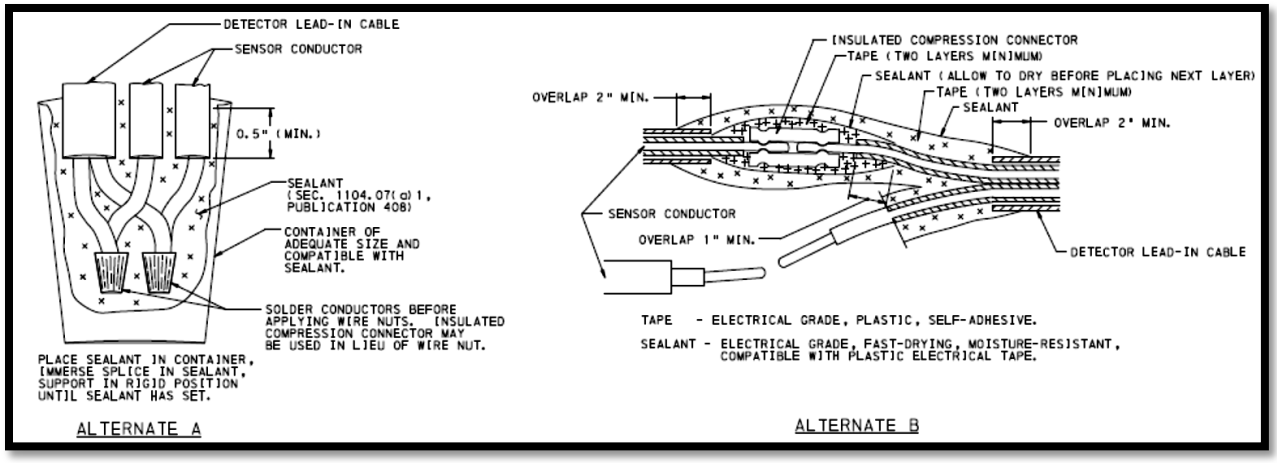
5.16.13 Use of Shielded Lead-in Cables

Unless the loop is located close to the cabinet that houses the detector amplifier (less than 75' is a good rule-of-thumb), the loop wire should be spliced to a shielded lead-in cable at a junction box before it is run to the cabinet.

5.16.14 Importance of Good Splice

The splice between the loop wire and the shielded lead-in cable is a potential weak point in the loop circuit and must be carefully constructed. Soldering of the connection is highly recommended, as is encapsulation of the soldered connection within a waterproof sealant. The use of a splice kit is another excellent way to ensure that a good splice is achieved and maintained.

Exhibit 5-51 Detector Splice from TC-8806



5.16.15 Twisting the Tail

The portion of the loop assembly located between the loop itself and the shielded lead-in cable is commonly referred to as the "tail." The unshielded loop wire located in the tail should be twisted at a rate of no less than five twists per 1'. Twisting the wires cancels out their inductance field, ensuring that unwanted vehicle detections do not occur at the tail. With caution, a power drill can be used to conveniently twist the tail.

5.16.16 Shielded Lead-in Cable

Shielded lead-in cable is typically constructed of AWG #14 or AWG #12 wire that is twisted at approximately 15 twists per 1' and is covered by an aluminum-polyester shield and encased in a continuous polyethylene outer jacket. The construction allows loop wires for different detectors to run in the same conduit for long distances without causing interference problems. The lead-in wire should meet IMSA specification 50-2.

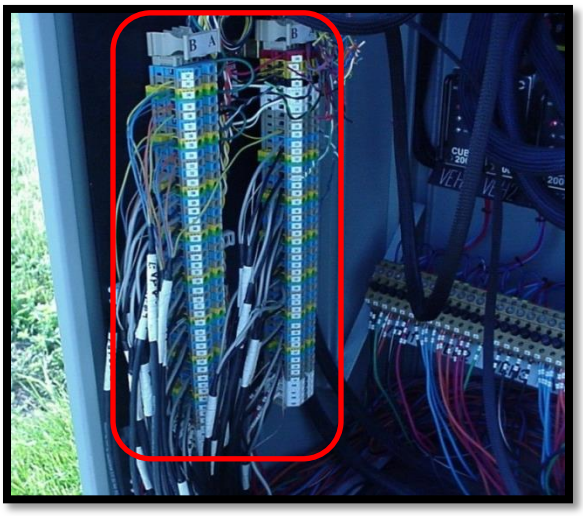
5.16.17 Loop Terminology

Sometimes, the portion of the loop assembly located between the loop itself (the tail) and the shielded lead-in cable is called a "home run" or BELDEN (Mfg. of lead-in cable). This inconsistency is confusing to those new to loop construction.

5.16.18 Loop Termination Panel

The loop field wires (either the shielded lead-in or the twisted tail) are connected to a loop termination panel located inside the controller cabinet. It is here that the loop wires interface with the detector unit.

Exhibit 5-52 Loop Termination Panel



5.16.19 Detector Unit

The detector unit senses the change in inductance caused by a vehicle passing over the loop and converts this information into an electrical signal that the traffic signal controller can recognize. The detector unit also energizes the loop, establishing the inductance field. The detector unit is located within the controller cabinet (see **Exhibit 5-53**) and is connected to both the loop termination panel and the controller by way of a detector harness, or as part of a wired rack assembly.

Exhibit 5-53 Detector Unit in Controller Cabinet

5.16.20 Loop Crosstalk

Crosstalk occurs between loops when the loops are located close together, are of similar size, and are operating on a similar frequency. Under these conditions, loops can activate others resulting in false vehicle detections.

5.16.21 Preventing Loop Crosstalk

In addition to keeping wires from different loops properly separated, crosstalk can be prevented by setting detectors that control adjacent loops to different frequencies. Many detectors have a switch that allows the user to select different frequencies. Another means of preventing crosstalk is to use multi-channel detectors that have internal circuitry, which automatically prevents crosstalk between loops that are attached.

5.16.22 Work Zone Protection During Loop Installation

Loop installation should not be attempted without proper work zone traffic control. Since installing the loops will require closing lanes, appropriate advance signing will be needed and, depending on the situation at hand, so will a flashing arrow board, a police officer, or properly trained flaggers to aid in traffic control. Keep in mind that additional traffic control measures need to be taken if the wire from the inductance loop to the nearest junction box must cross other lanes of traffic.

5.17 Final Clean Up

When construction of the signal is complete, the area should be returned to a condition that is similar to the condition that existed before construction began. Any damage caused by the construction activities should be repaired and the area cleared of all construction-related debris.

5.18 As-Built (Record) Plans

Once the signal installation has been accepted, as-built (record) drawings need to be made and sent in with the semi-final records. Any part of the installation of the traffic signal that differs from the original design needs to be noted so that others have accurate information as to how it was built. Especially important to note for traffic signal projects are changes in:

- ✓ location of junction boxes
- ✓ vehicle signal heads
- ✓ conduit runs
- ✓ wiring
- ✓ pole locations
- ✓ utilities

The as-built drawings should be clean, neat and accurately prepared. All field changes should be made at the earliest possible date and not trusted to the memory of the recorder.

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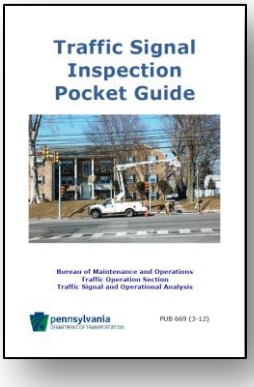
CHAPTER 6. TRAFFIC SIGNAL INSPECTION

6.1 Introduction

This chapter will focus on traffic signal inspection. The key PennDOT document for traffic signal inspection is Publication 669, Traffic Signal Inspection Pocket Guide (see Section 2.2 on page 2-2). The information in this chapter is laid out to match that of Publication 669 with some additional details added. Be sure to check for the latest version of Publication 669 for project work.



6.1.1 Purpose of Publication 669

Publication 669 and this chapter are intended to assist the Inspector (either on construction projects or Highway Occupancy Permit projects) in recognizing the components of a traffic signal, ensuring that all contract requirements are met in the traffic signal installation, and as a roadmap to the PennDOT traffic signal requirements.

Although most common situations are addressed by standards, specifications and this manual, not all situations may be covered and may require additional assistance from the District Signal Supervisor. Additionally, if field conditions differ from those shown on the plan or something doesn't seem to make sense, contact the Inspector In-Charge and the District Signal Supervisor as soon as possible to determine the proper course of action. District contact information can be found in Section 1.9 on page 1-7.

6.1.2 Authorization for Inspection

The work on traffic signal construction projects will be subject to the inspection of the representative or authorized assistants. They should be provided access to the worksite and furnished with every reasonable facility for determining whether the work being performed, or has been completed, is according to the requirements of the plans, specifications, and contract, except as otherwise provided.

6.1.3 Responsibilities of the Inspector and District Traffic Unit

Responsibilities of the inspector and District Traffic Unit are described in Sections 1.6 and 1.7, respectively.

6.1.4 General Inspection Principles

It is important that everyone involved in a traffic signal construction project closely adhere to the contract documents. Any deviation from the drawings should only be done after consultation with the District Signal Supervisor.

The inspector/Department will work with the contractor to ensure the safe and efficient flow of traffic during construction. All parties should take into account the future operational needs and municipal maintenance of the traffic signal.

6.1.5 Submittals and Approvals

The following is the general process for traffic signal construction process submittals and approvals.

1. Verify that the contractor completes and submits the CS-201 "Source of Supply-Traffic Items" (see Section 2.12) and receives required approvals for all materials, equipment, and hardware from the District Materials Unit and/or District Traffic Unit prior to installation. Sometimes this process can be lengthy, so the initial submissions should be made early in the project.
2. Typical materials requiring prior approval as specified in Section 1104.01 of Publication 408 are:
   - ✓ Traffic Signal structural support (PennDOT approved shop drawing)
   - ✓ Traffic Signal controllers
   - ✓ Flasher units
   - ✓ Signal (vehicular and pedestrian) and Light Emitting Diode (LED) modules
   - ✓ Detector amplifiers and/or detection systems
   - ✓ Preemption systems (if applicable)
   - ✓ Pedestrian pushbuttons and Accessible Pedestrian Signals (APS) (if applicable)
   - ✓ Electrically operated signs (if applicable)
3. Work with the contractor to submit the following:
   - ✓ Three copies of the cabinet wiring diagram and manufacturer's timing plan for each controller assembly. If there are changes to the timing plan during testing, three new sets of timing plans are required.
   - ✓ Three copies of warranties, guarantees, instruction manuals, wiring diagrams and parts lists. Controller Assembly Instruction Manuals are to be placed in each controller cabinet.
   - ✓ Two keys for each controller cabinet lock (Two for the Number 2 cabinet lock and two police keys).
   - ✓ Shop drawings and calculations for approval for all traffic signal supports on the project. The shop drawings are to be stamped by a Professional Engineer registered in Pennsylvania.

6.1.6 Miscellaneous Requirements and Information

1. Verify that the contractor permanently marks the following materials with the manufacturer's name, serial number and model or part number:
   - ✓ Controller Unit
   - ✓ Conflict Monitor
   - ✓ Flashers
   - ✓ Relays
   - ✓ Load Switches
   - ✓ Time-base Units, including GPS units
   - ✓ Detector Amplifiers
   - ✓ Detector Power Supplies
   - ✓ Detection Systems & equipment
   - ✓ Interfaces
   - ✓ Modems
   - ✓ Emergency Vehicle Preemption Units
   - ✓ Uninterrupted Power Supply (UPS) System
2. Verify that the contractor maintains removed controller assemblies as a unit and stores the material at the project site in a secure location. For further information, refer to Publication 408, Section 1104.01.
3. Contact the District Signal Supervisor at least 7 calendar days before marking pole locations so it may be determined if a Traffic Unit Representative should be present.
4. Verify that, after the new installation is operational, the contractor removes all existing traffic signal supports (including those with traffic signals), flashing warning devices, and lane control signs and signal equipment, unless otherwise directed. All equipment removed shall be returned to the municipal traffic signal owner. The contractor should maintain removed controller assemblies as a unit and the material should be stored at the project site. The contractor should prepare a listing of the equipment for the municipal owner, make arrangements to deliver the equipment to the municipal storage area and receive a written receipt acknowledging receipt of the equipment. It is the contractor's responsibility to coordinate this transfer.
5. Document any damage to the equipment before its removal. The contractor is responsible for equipment damage during removal or storage. The contractor should provide notification to the inspector that the equipment was properly transferred to the municipal signal owner.
6. Unless otherwise noted, underground conduit, conductors, and detectors not interfering with new construction can be left in place. Foundations and junction boxes that are to be abandoned and are located outside of the shoulder area should be removed to one foot below final grade. Check with the Inspector In-Charge to determine what can be left in place. The

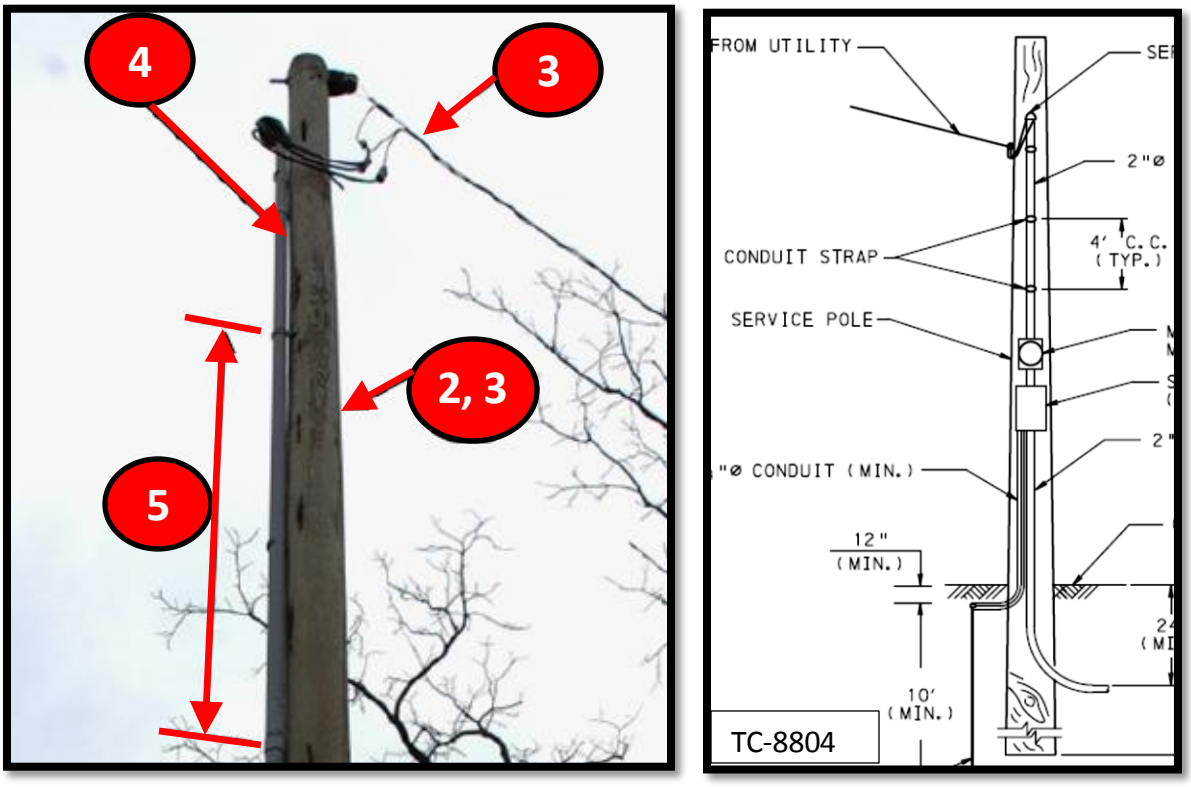
contractor is responsible for disposal of the removed materials and to properly fill, compact, and landscape the resulting hole, including adding topsoil if necessary.

7. If there are any questions concerning deviation from Publications 408 and 148, the special provisions and the contract plans, it is critical that the Inspector contact the Inspector In-Charge and the District Signal Supervisor.
8. Existing traffic signals are to remain and continue their current operation until the new signal is operable, absent any provisions to the contrary. If an existing traffic signal must be turned off or turned to flashing operations, work with the contractor to provide flaggers or police control and obtain approval from the District Signal Supervisor and municipal signal owner prior to modifying the existing operation.
9. If any vegetation is obstructing the visibility of traffic signal indications (vehicular and pedestrian) or signs, work with the contractor to request and obtain approval to remove the obstructions.
10. Verify that the contractor identifies possible utility conflicts early. Contact the District Utility Coordinator and District Signal Supervisor to determine the corrective action if a utility conflict exists.
11. Verify that conflicting signs are bagged immediately after the signal is turned on. If the signs are to be removed, they should be removed as soon as possible.
12. Obtain from the contractor the name and telephone number of the person to be notified in the event of failures or malfunctions during the guarantee period.

6.2 Electrical Service Connections

6.2.1 Electrical Service Type A (Wood Poles)

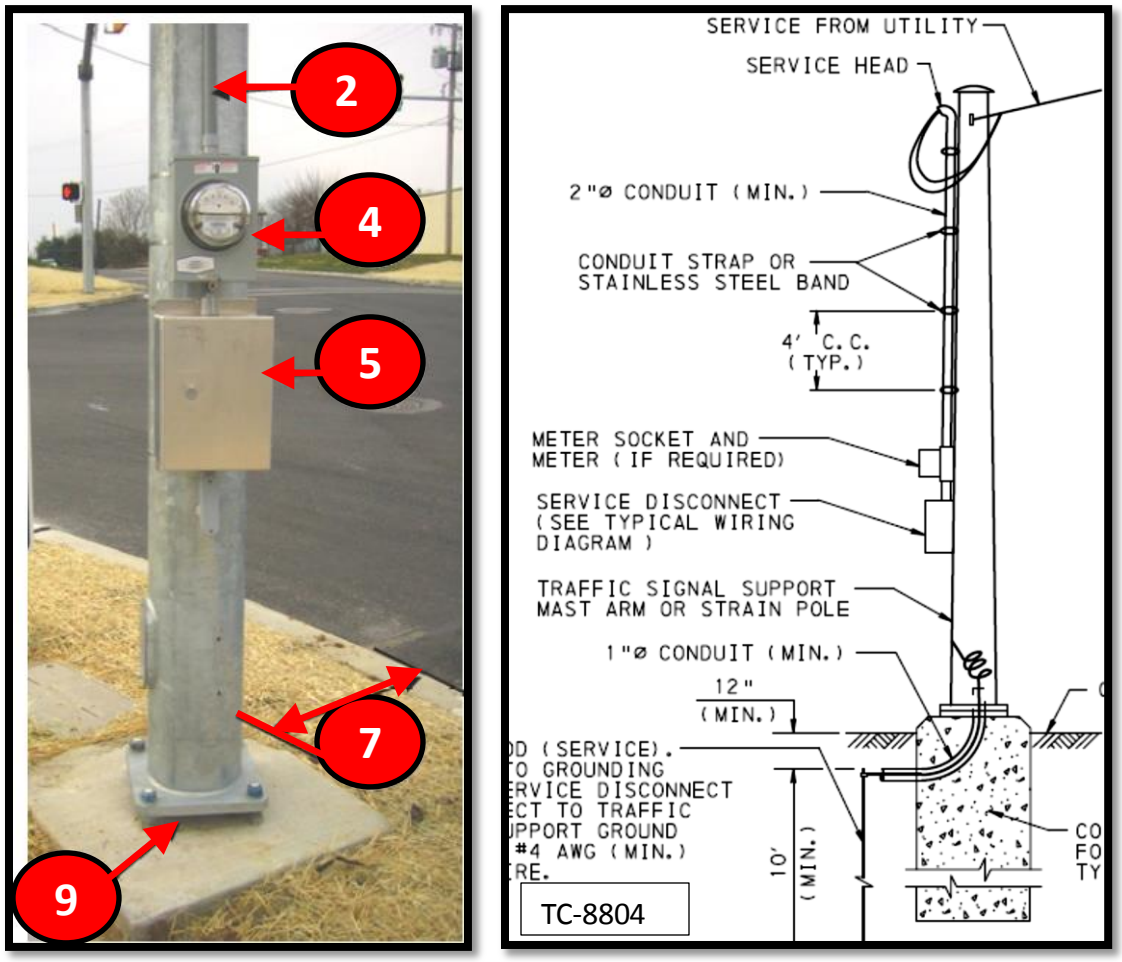
Exhibit 6-1 Electrical Service Type A (Wood Poles)



1. Verify the Contractor coordinates with the utility company for location of the service feed.
2. Verify that wood utility poles are 30’ – 40’ high and set a minimum of 6’ below grade on the low side of the sloped grade. Publication 408 Sections 910.3(k) & 1101.11(a)
3. Verify that poles are tall enough to provide proper vertical clearances for all attached wires, span wires and cable.
4. Verify that a minimum, 2” diameter, hot-dipped galvanized rigid metallic conduit with a service head is used. TC-8804 Sheet 1, Publication 408 Sections 954, 1101.09 & 1104.05(a).
5. Verify that conduit straps are no further apart than 4’ center to center. TC-8804 Sheet 1
6. Verify the contractor coordinates the meter type and socket with the utility company. Publication 408 Section 1104.05 (d)3)
7. Verify that a service disconnect without an external handle is included. TC-8804, Publication 408 Sections 954 & 1104.05(d)
8. Verify that a minimum 2” diameter conduit goes between the service disconnect and the controller to carry service conductors.
9. Verify there is a ¾” minimum diameter conduit with a minimum #4 AWG grounding conductor connected to the ground rod and to ground bus in the service disconnect.

6.2.2 Electrical Service Type B (Steel Poles)

Exhibit 6-2 Electrical Service Type B (Steel Poles)



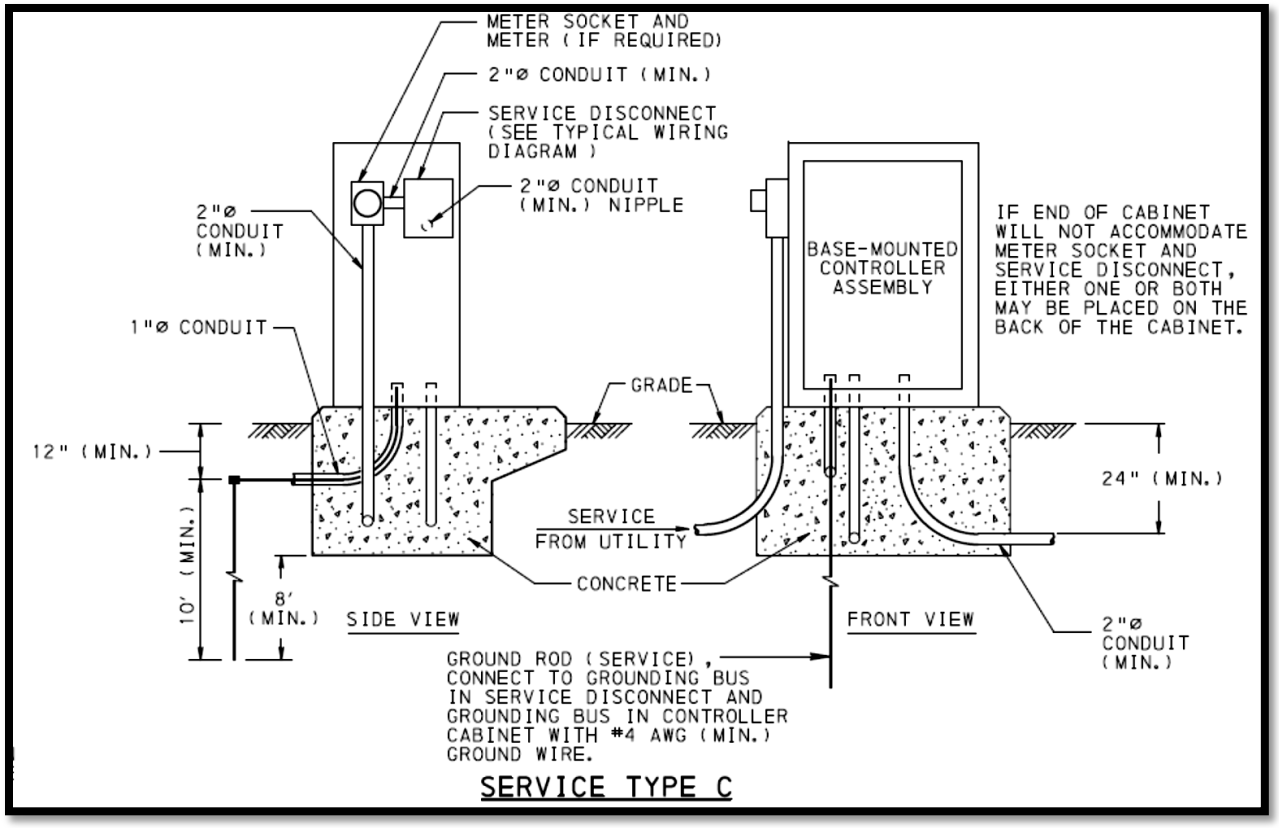
1. Verify that contractor coordinates with the utility company for location of the service feed.
2. Verify that a minimum, 2” diameter, hot-dipped galvanized rigid metallic conduit with service head is used for service unless otherwise required by the utility company. TC-8804 Sheet 1, Publication 408 Section 954 & 1101.09
3. Verify that conduit straps are no further apart than 4’ center to center. TC-8804 Sheet 1
4. Verify the contractor coordinates the meter type and socket with the utility company. Publication 408 Section 1104.05(d)3
5. Verify that a service disconnect without an external handle is included. TC 8804 Sheet 1, Publication 408 Sections 954 & 1104.05(d)
6. Verify there is a 1” minimum diameter conduit in pole foundation with #4 AWG minimum grounding conductor to ground rod in earth adjacent to pole foundation.
7. Verify the minimum clearance as indicated in Pub 149 is obtained. TC- 8801 sheet 1

8. Verify the electrical utility inspection occurred or was waived by the utility company. Publication 408, Section 954.3 (f))
9. Verify that non-shrink mortar is used beneath the base plate in paved areas and metal screening is placed beneath the base plate in unpaved areas. Pub. 408 sec. 951.3(c)) TC- 8801
10. Clearances vary by facility, voltage and owner. If there is a question of appropriate clearance, contact the District Utility Administrator

6.2.3 Electrical Service, Type C (Installed on base mounted controller cabinet)

1. Verify the contractor coordinates the meter type and socket with the utility company. Publication 408 Section 1104.05 (d)3)
2. Verify that a minimum 2" diameter hot dipped galvanized rigid metallic conduit and fittings are used for service unless otherwise required by the Utility. TC-8804
3. Verify that a galvanized rigid steel 2" conduit is used between the meter and the disconnect enclosure. TC-8804
4. Verify that a galvanized rigid steel 2" conduit and fittings are used between the disconnect enclosure and the controller cabinet. TC-8804

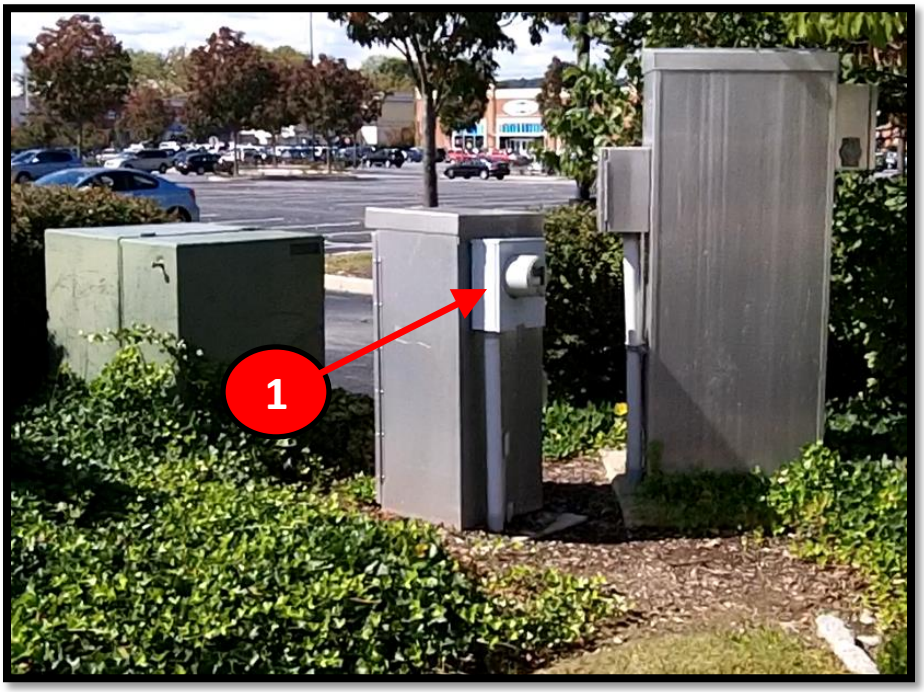
Exhibit 6-3 Electrical Service Type C



6.2.4 Meter Socket and Disconnect (All Service Types)

1. Verify the contractor coordinates the meter type and socket with the utility company. TC-8804 and Publication 408 Section 1104.05(d)3
2. Verify that service conductors to the utility company connection point are #2 AWG minimum and, if required by the utility company, the correct color. Publication 408 Section 1104.05(b)2 & TC-8804.
3. Verify the power line surge protector is in accordance with Publication 408 Section 1104.05(d)4.e & TC-8804 Sheet 1
4. Verify the service disconnect is rated at a minimum of 100 amps or as required by power company. TC-8804
5. Verify that ungrounded conductors, grounded conductors, and equipment grounding conductors to traffic controller are a minimum of #8 AWG. TC-8804
6. Verify that a galvanized steel, stainless steel, or aluminum service enclosure with hinged door and provisions for a padlock conforming to NEMA Standard Type 3R, 3S, or 4 is provided. Publication 408 Section 1104.05(d)4.a
7. Verify the ground wire is either bare or green insulated #8 AWG minimum. Publication 408 Section 1104.05(b)3
8. Verify the grounding electrode from service is connected to the grounding lug inside the enclosure with a #4 AWG conductor. Publication 408 Section 1104.05(f) & TC-8804

Exhibit 6-4 Meter Socket and Disconnect



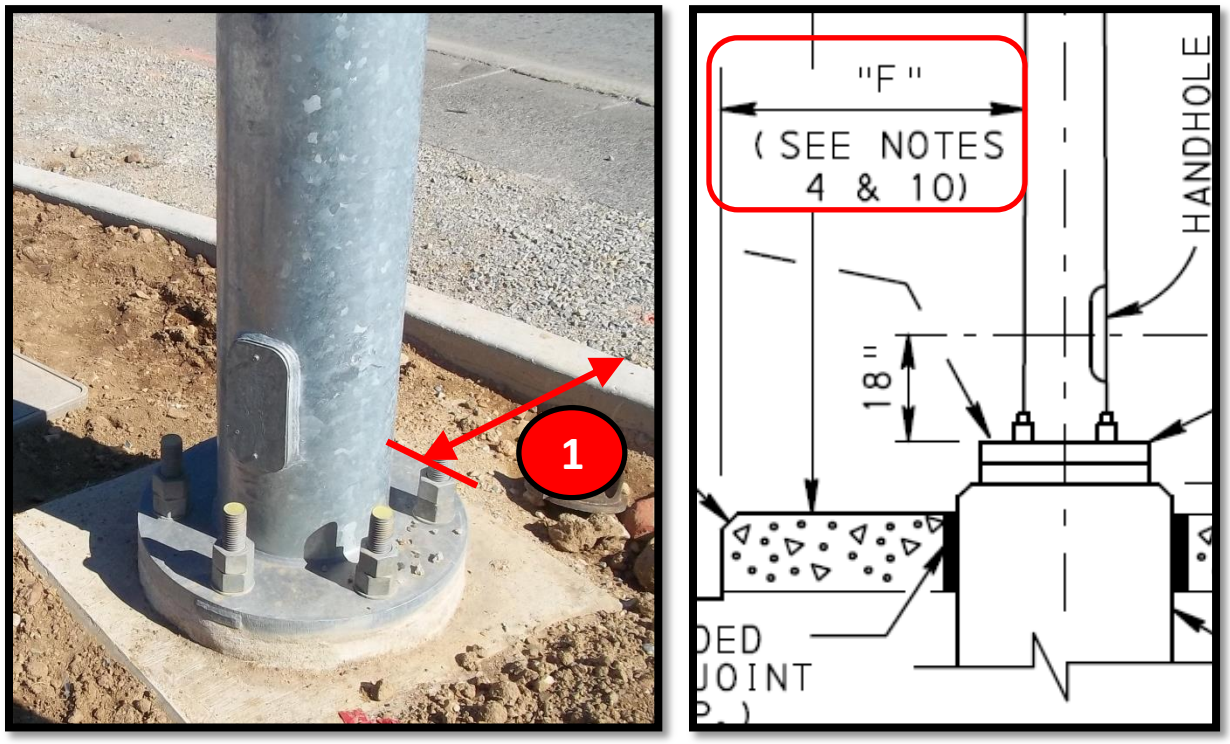
6.3 Traffic Signal Structural Supports

Refer to Publication 408 Sections 951 and 1104.02 for further details.

6.3.1 Foundations

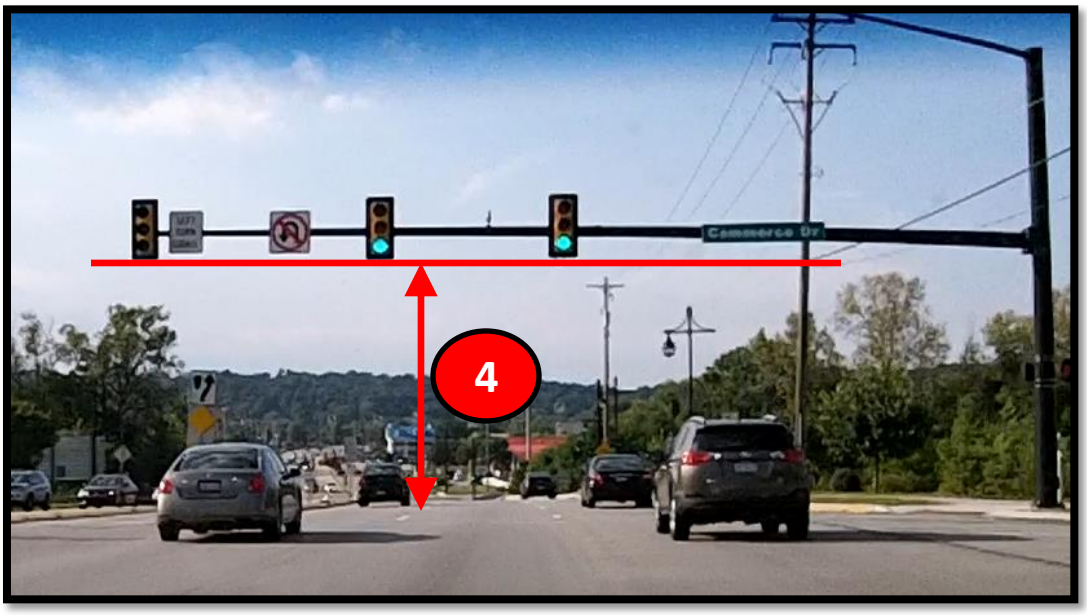
1. Field-verify that traffic signal supports are located in accordance with the approved plans and the minimum clearance as indicated in Pub 149 is obtained. TC-8801 sheet 1
2. Verify the "Pennsylvania One Call System (#811)" notification was completed by the contractor and all acceptable clearances were obtained.
3. Contact the District Signal Supervisor to resolve any conflicts between existing utilities and the plan location of any support foundation.

Exhibit 6-5 Foundations



4. Verify the elevations for the traffic signal support foundations ensure proper clearance above the roadway to the bottom of signal heads and/or signs and/or tether wire. The signal contractor is responsible for coordination with the prime contractor in determining pole foundation elevations. Changes to grades shown on the drawings must be factored into the signal contractor's determination of shaft height and foundation elevations. See TC 8801

Exhibit 6-6 Clearance between Roadway and Signal Heads and Signs

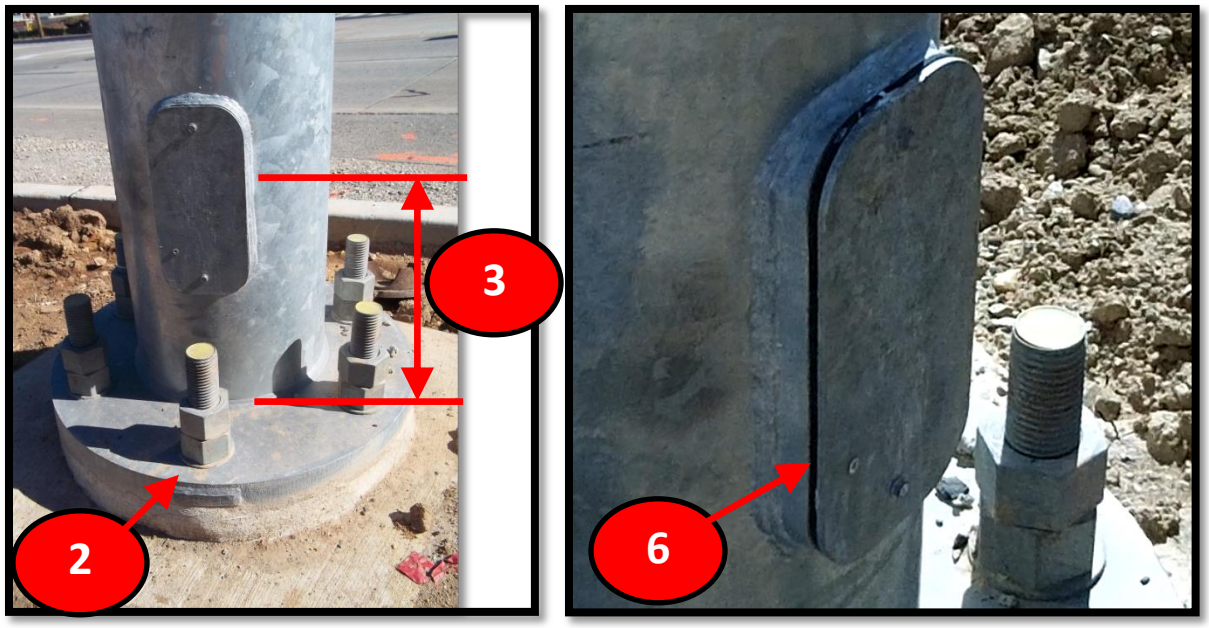


5. Verify foundation type, depth and rebar configuration in TC- 8801, which are determined by the following:
   - ✓ Approved Traffic Signal Support-mast arm length.
   - ✓ Approved Traffic Signal Support-Strain Pole-design tension and shaft length.
6. For a foundation within a sidewalk area, verify the top of the foundation will be flush with the final finished surface.
7. For a foundation outside a paved sidewalk, verify the top of the foundation will be at least 6“above the surrounding surface.
8. Verify that anchor bolts are clean, protected and placed at the same elevation. Verify the bolt projection is sufficient to rake the support properly.
9. Verify the contractor has used the proper length anchor bolt considering the required embedment length and required projection as shown on TC-8801.
10. Verify that all conduits are in place and will be able to fit within the footprint of the pole when it is set. The conduits must have 24” of cover to the top of subbase when they exit the foundation.

6.3.2 Traffic Signal Supports

1. Verify that traffic signal supports were inspected in the fabrication plant in accordance with Publication 408 Section 1104.01.
2. Verify that base plate anchor bolts, nuts and washers are installed and tightened in accordance with Publication 408 Section 1104. Verify the distance between the bottom of each leveling nut and the concrete foundation is less than the bolt diameter.
3. Verify the center line of the hand hole is 18" above the base plate. TC-8801
4. Verify the minimum area of hand hole is 25 square inches with a minimum unobstructed width of 3.5". TC-8801
5. Verify the opening in the hand hole frame is 7" in height, 3 1/2" in width, cut from 3" thick plate and protrudes from pole ¾" minimum. TC-8801 sheet 10
6. Verify the cover plate is ¼" x 5" x 8" with a neoprene gasket cemented on and that it is tightly secured to the pole with fasteners. TC-8801
7. Verify the ground lug is attached to the hand hole frame within the pole cavity. TC-8801

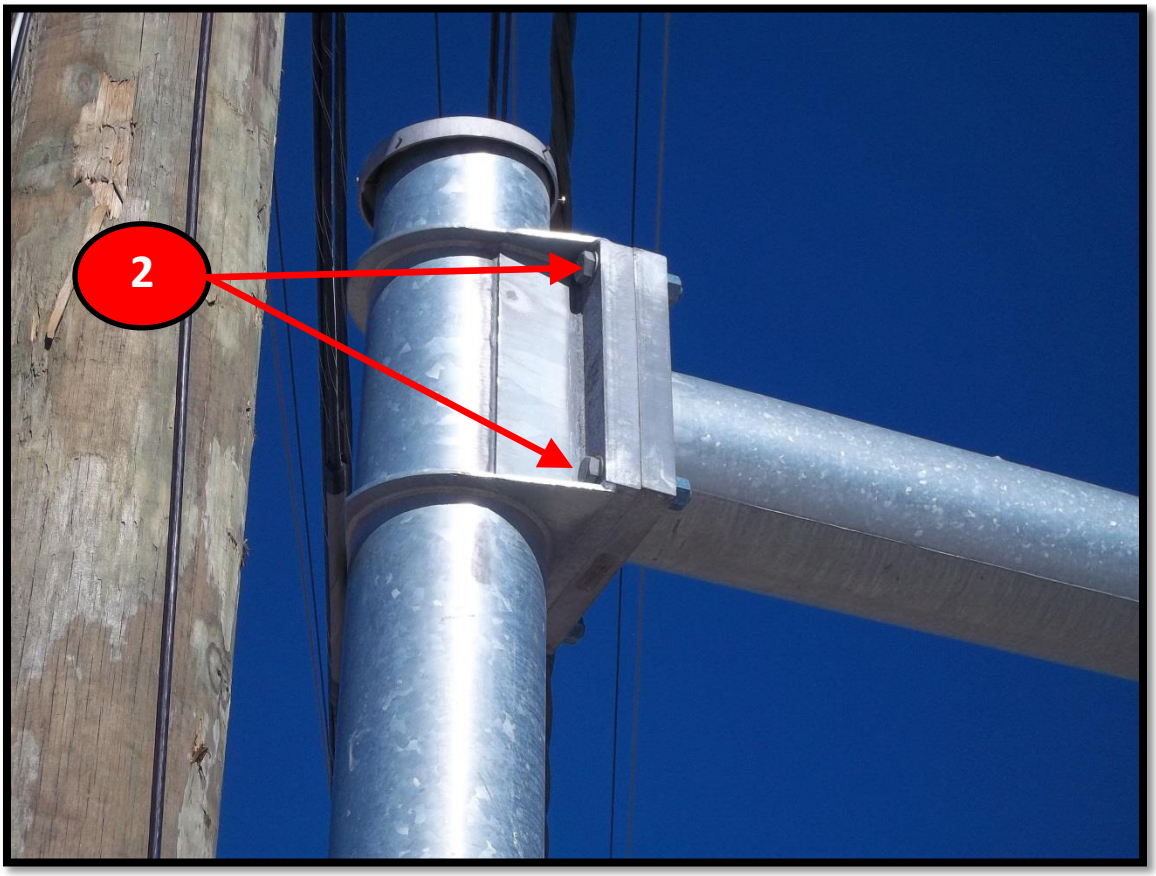
Exhibit 6-7 Traffic Signal Supports



6.3.3 Mast Arms

1. Verify the hand hole is installed 90° or 180° from the centerline of arm "A." TC-8801
2. Verify that approved and tested high-strength bolts, nuts and washers are used to connect the mast arm to the pole shaft.
3. Verify the observations for galloping as required by TC- 8801, sheet 1 of 10, note 16 are made.
4. Clearances vary by facility, voltage and owner. If there is a question of appropriate clearance, contact the District Utility Administrator.

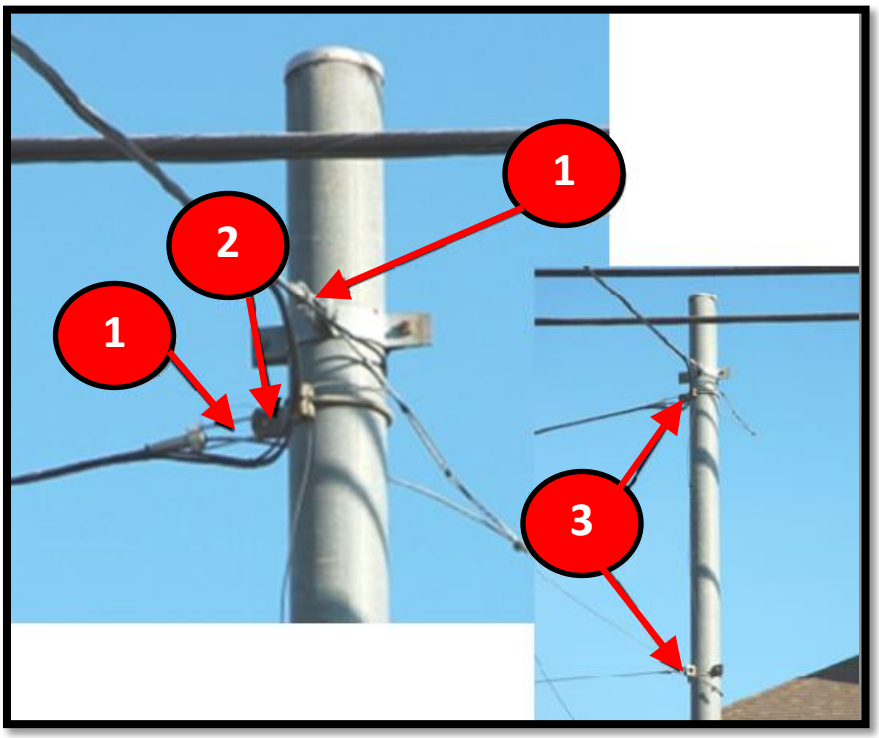
Exhibit 6-8 Mast Arm Connection



6.3.4 Strain Pole

1. Verify, with a visual inspection from the ground, that the span wire is attached using a clamp with dead-end, feed-thru, strand-vise with stainless steel bail. TC-8801
2. Verify, with a visual inspection from the ground, that the bonding clamp is suitable for use with any combination of copper, steel, or aluminum conductors. TC-8801
3. Verify, with a visual inspection from the ground, that the span wire and the tether wire are electrically bonded to the strain pole. Use a minimum #4 AWG bare copper, connected to the span wire and tether wire and attached with a lug to the strain pole or another method that assures electrical connectivity. TC-8801

Exhibit 6-9 Strain Pole



4. Clearances vary by facility, voltage and owner. If there is a question of appropriate clearance, contact the District Utility Administrator.
5. Verify that all tether clamps used to secure the bottom of a sign or signal head to a tether wire have sheet lead wrapped over the tether wire at the clamp connection and the lead extends out both sides of the clamp approximately 1/4".
6. Verify the tether cable clamp at the bottom of the signal housing is positioned correctly per TC-8801, Detail III.

7. Verify the span wire used has breaking strength equal to or exceeding the design tension. TC-8801
8. Verify that signal heads are attached with span wire hanger, balance adjuster, cable entrance adapter and pipe as required to place top of all signs and signal heads at the same elevation. TC-8801
9. Verify that ¼" diameter tether wire is used. TC-8801
10.
    - ✓
    - ✓
    - ✓
    - ✓
    - ✓
    - ✓

Exhibit 6-10 Strain Pole

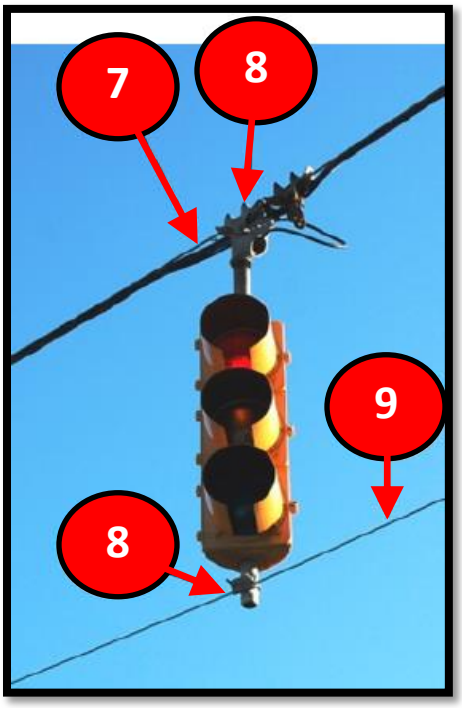
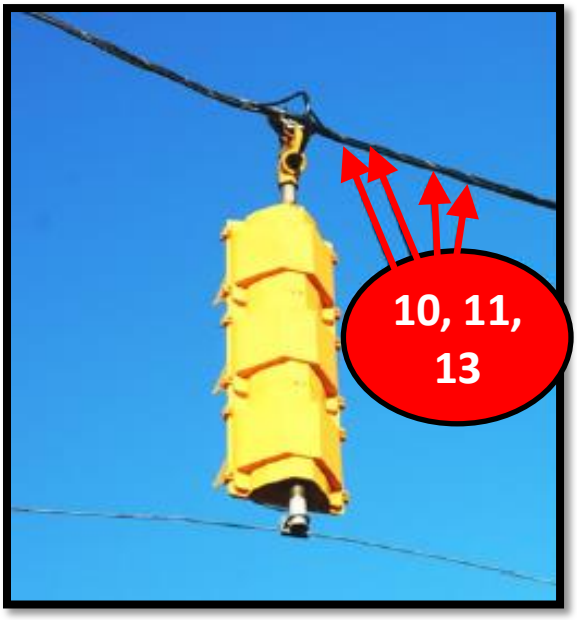
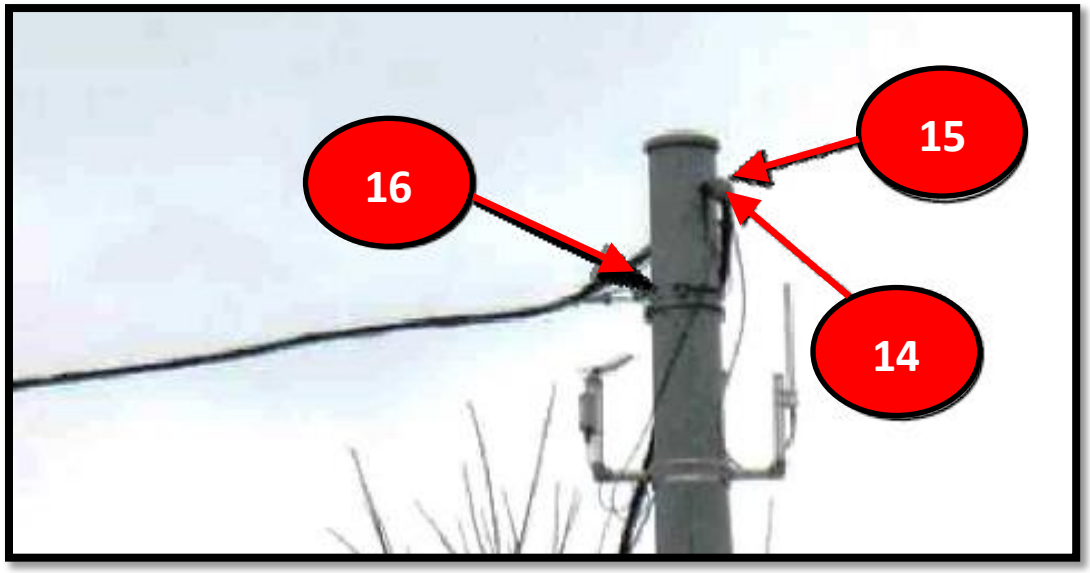


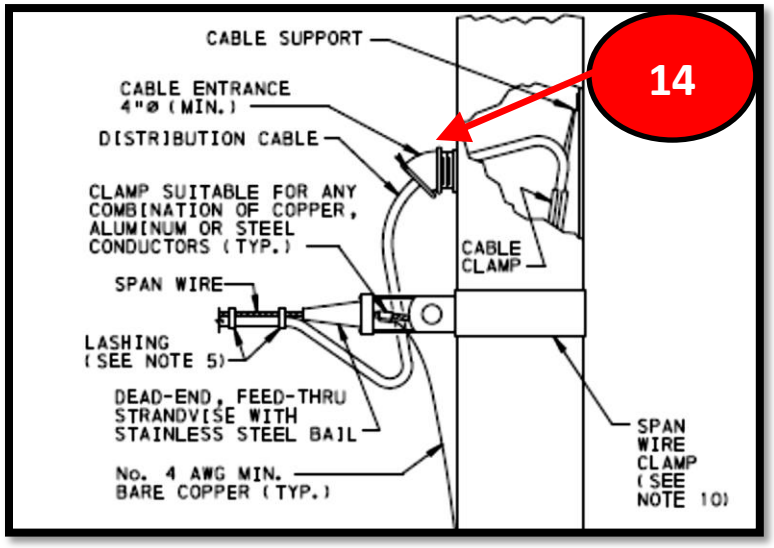
Exhibit 6-11 Strain Pole



11. Verify that lashing of the distribution cable to the span wire is accomplished with one of the following:
    - ✓ Preformed galvanized steel rods
    - ✓ Self-locking cable ties of outdoor type
    - ✓ Solid copper wire
    - ✓ Galvanized steel wire
    - ✓ Stainless steel wire
    - ✓ Cable rings and saddles
12. Verify that wire lashing makes one complete wrap at intervals not exceeding 6”.
13. Verify that ends of wire lashing are secured to the span wire with an all-purpose split bolt connector.
14. Verify that cable ties are at intervals not exceeding every 12”.

Exhibit 6-12 Strain Pole





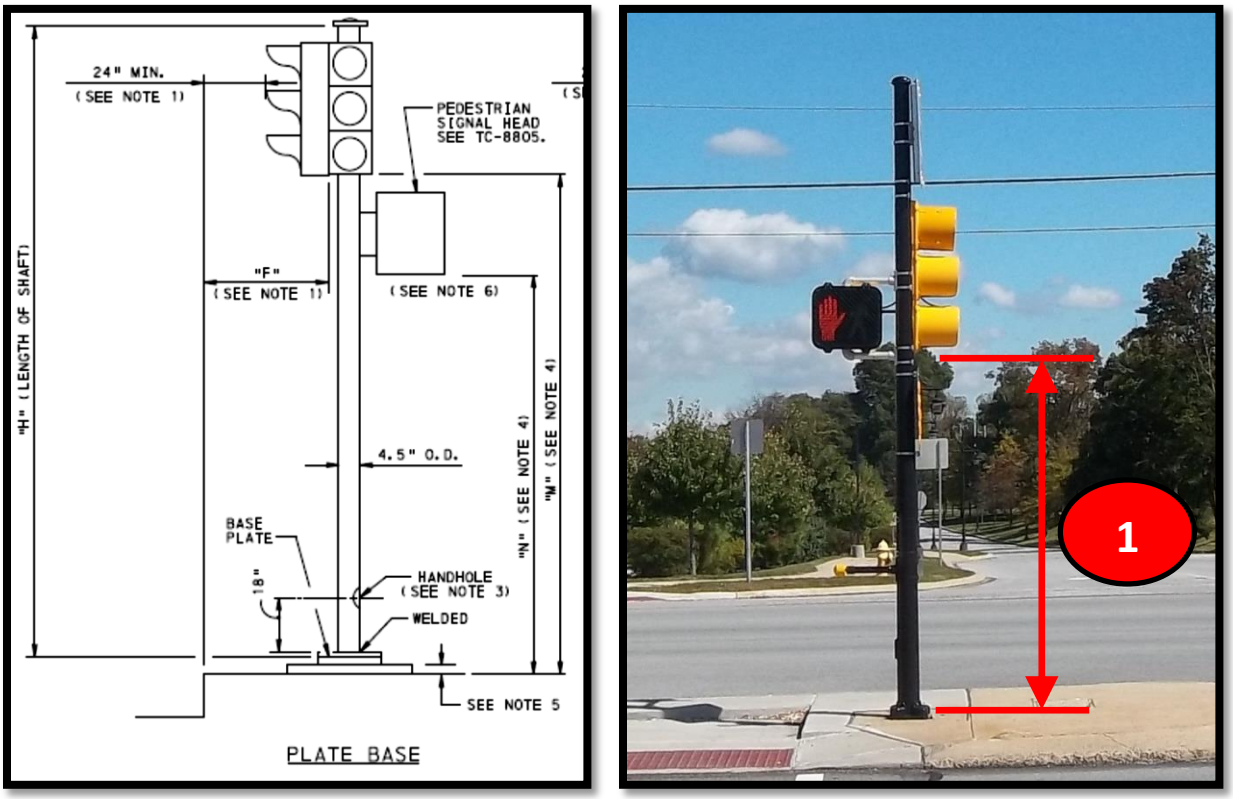
15. Verify the cable entrance is a minimum of 4” in diameter. TC-8801
16. Verify, with a visual inspection from the ground, that an insulated grommet is used for weather proofing the wire inlet. Publication 408 Section 1104.02(a)6
17. Verify, with a visual inspection from the ground, the span wire and an individual clamp is used for each span wire or tether wire. TC-8801

6.3.5 Pedestal Poles

Pedestal Poles (Base Plate Type)

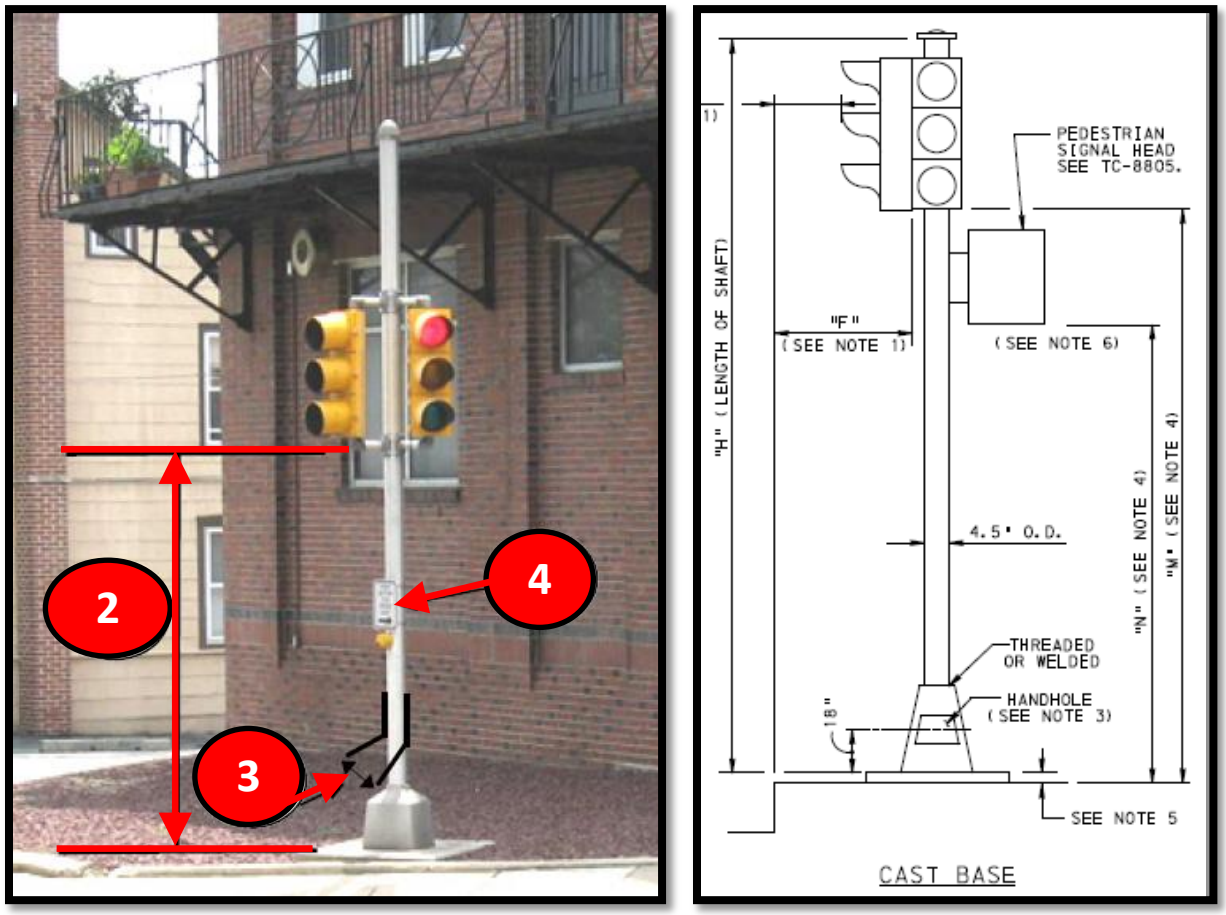
1. Verify the pole is tall enough to provide 8’ minimum, 10’ maximum height above grade to bottom of signal housing. TC -8803
2. Verify that hand hole opening is 3” x 5” with a minimum frame thickness of 3/8” and the centerline is 18” above the base plate. TC-8803 and TC-8801
3. Verify the base plate is continuously welded to the pole. TC-8803
4. Verify that non-shrink mortar is used beneath the base plate in paved areas and metal screening is placed beneath the base plate of the pole in unpaved areas. Pub. 408 sec. 951.3 (c))
5. After erection of pole and mounting of signal hardware, verify the minimum clearance as indicated in Pub 149 is obtained from curb to the nearest element of the pole or signal head. TC-8801, TC-8803

Exhibit 6-13 Pedestal Poles (Base Plate Type), TC-8803



Pedestal Poles (Cast Base Type)

Exhibit 6-14 Pedestal Poles (Case Base Type)

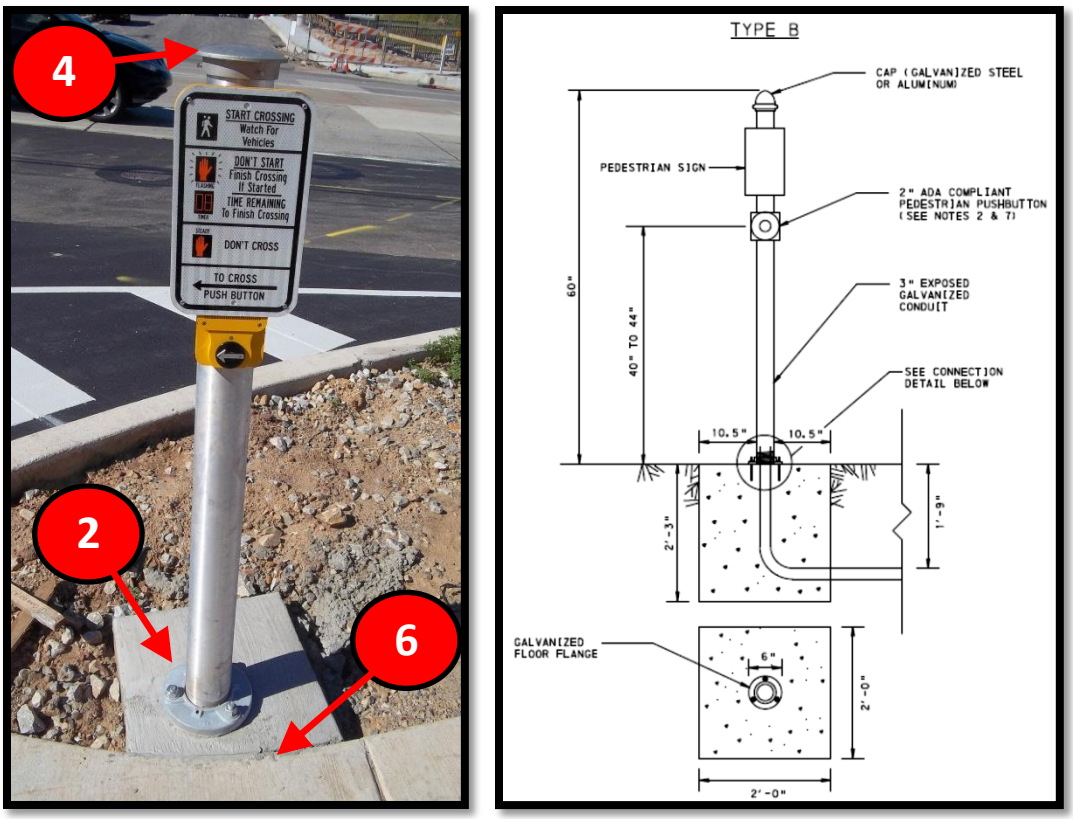


1. Verify the hand hole opening is 3” x 5” with a minimum frame thickness of 3/8”. TC-8803 and TC-8801
2. Verify the pole provides 8’ minimum, 10’ maximum height above grade to bottom of signal head. TC-8803
3. Verify the outside diameter of the pole is 4.5”. TC-8803
4. Verify the contractor coordinates the direction of the “Push Button” sign with phase called by associated push button. TC-8803
5. Verify the pole-to-cast base connection is threaded or welded. If threaded, make sure locking screw(s) are in place and tight to prevent turning of pole in cast base.
6. After erection of pole and mounting of signal hardware, verify the minimum clearance as indicated in Pub 149 is obtained from curb to the pole or nearest part of the signal housing. TC-8801, TC-8803
7. Verify that pedestal poles are set plumb and level.

6.3.6 Pedestrian Pushbutton Poles

1. Verify that poles are placed correctly in relation to the location of the curb ramps. TC-8803
2. Verify the pole foundations are correct for the type of pushbutton pole being installed TC-8803
3. Verify the poles are 3” Galvanized Rigid Steel Conduit, except Type C and Type F poles which should be 4.5” O.D. Schedule 40 TC-8803
4. Verify the top of the pole is 60” (5’) above finished grade and that a galvanized steel or aluminum cap is in place. TC-8803
5. Verify that all accessibility features are compliant with PennDOT Publication 13M (DM-2), Chapter 6, Publication 72M (RC Standards) criteria and Publication 149. TC-8803
6. Verify the top of the foundation is flush with the surface of adjacent pavement when installed in pavement and that there is a 1/2" pre-molded expansion joint filler between foundation and adjacent pavement. TC-8803
7. Verify that if a pedestrian pushbutton extension arm is used, it is 3” or less. If it measures between 3" to 12", obtain District Office approval prior to installation. Do not allow installation of arms longer than 12”. TC-8803

Exhibit 6-15 Pedestrian Pushbutton Poles



6.3.7 Wood Poles

1. Verify that temporary wood poles are in accordance with Publication 408 Section 1104.02(f).
2. Verify the contractor installs service poles in accordance with Publication 408 Section 910.3(k).

6.4 Traffic Signal Subsurface Facilities

Refer to Publication 408 Sections 954 and 1104.05 for further details.

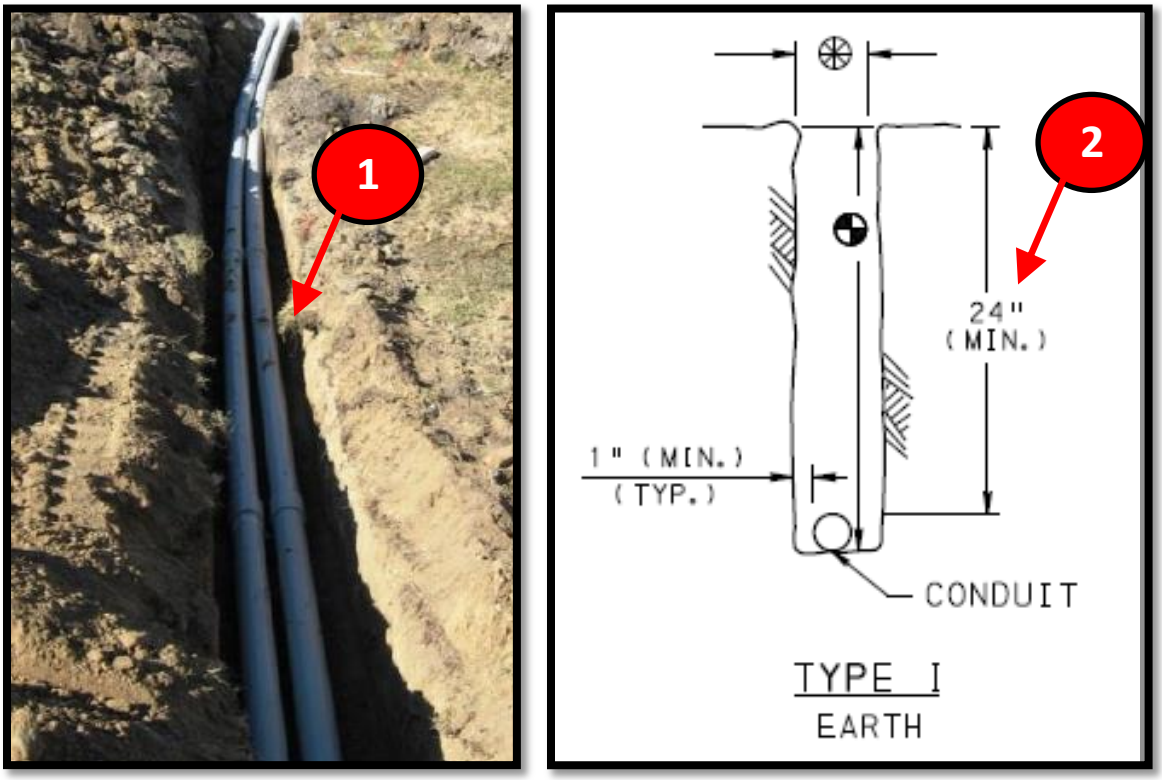
6.4.1 Trench and Backfill

Trench and Backfill Type I (in earth)

TC-8804 Sheet 2 and Publication 408 Section 954.3

1. Verify the trench is wide enough to allow proper installation, backfill and compaction of the trench and that at least 1" can be maintained between each conduit and between the conduit and the edge of the trench.
2. Verify the trench is deep enough to provide at least 24" of cover to the top of the conduit. TC-8806
3. Verify that plastic marking tape is placed in the last layer of back-fill material for the entire length of the trench. Publication 408 Section 910.3.(c)

Exhibit 6-16 Trench in Earth (Type I)

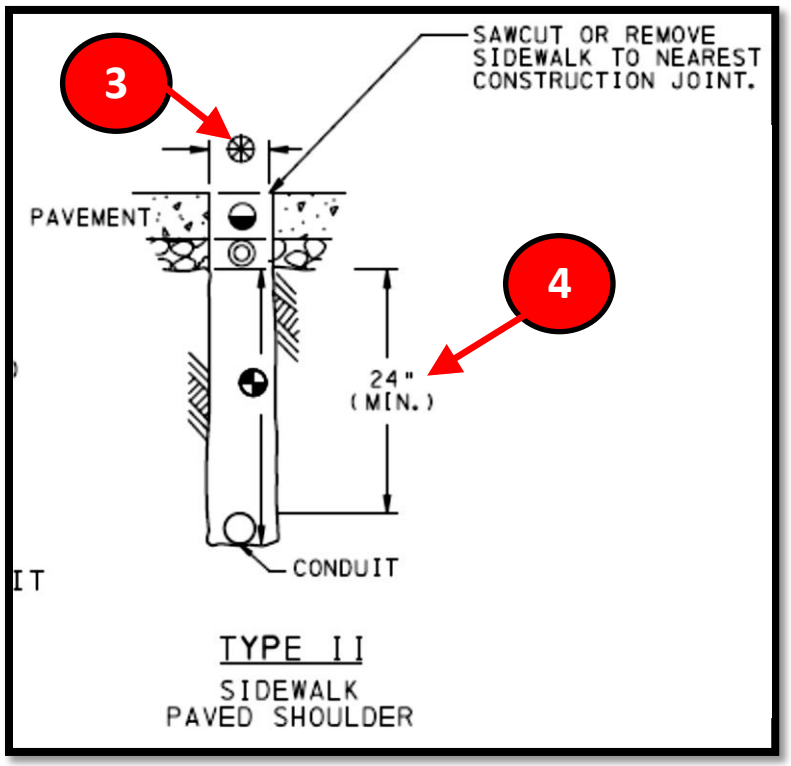


Trench and Backfill Type II (in sidewalk or paved shoulder)

TC-8804 Sheet 2 and Publication 408 Section 954.3

1. Verify that special provisions do not call for special actions including full sidewalk slab replacement.
2. Verify the sidewalk or paved surface is saw-cut at the nearest construction joint.
3. Verify the trench is wide enough to allow proper installation, backfill and compaction of the trench and that at least 1" can be maintained between each conduit and between the conduit and the edge of the trench.
4. Verify the trench is deep enough to provide at least 24" of cover from the top of the conduit to the bottom of the sub-base.
5. Verify that plastic marking tape is placed in the last layer of back-fill material for the entire length of the trench. Publication 408 Section 910.3.(c)
6. Verify the sub-base is replaced in kind.
7. Verify the pavement surface is replaced in kind.

Exhibit 6-17 Trench in Paved Shoulder (Type II)

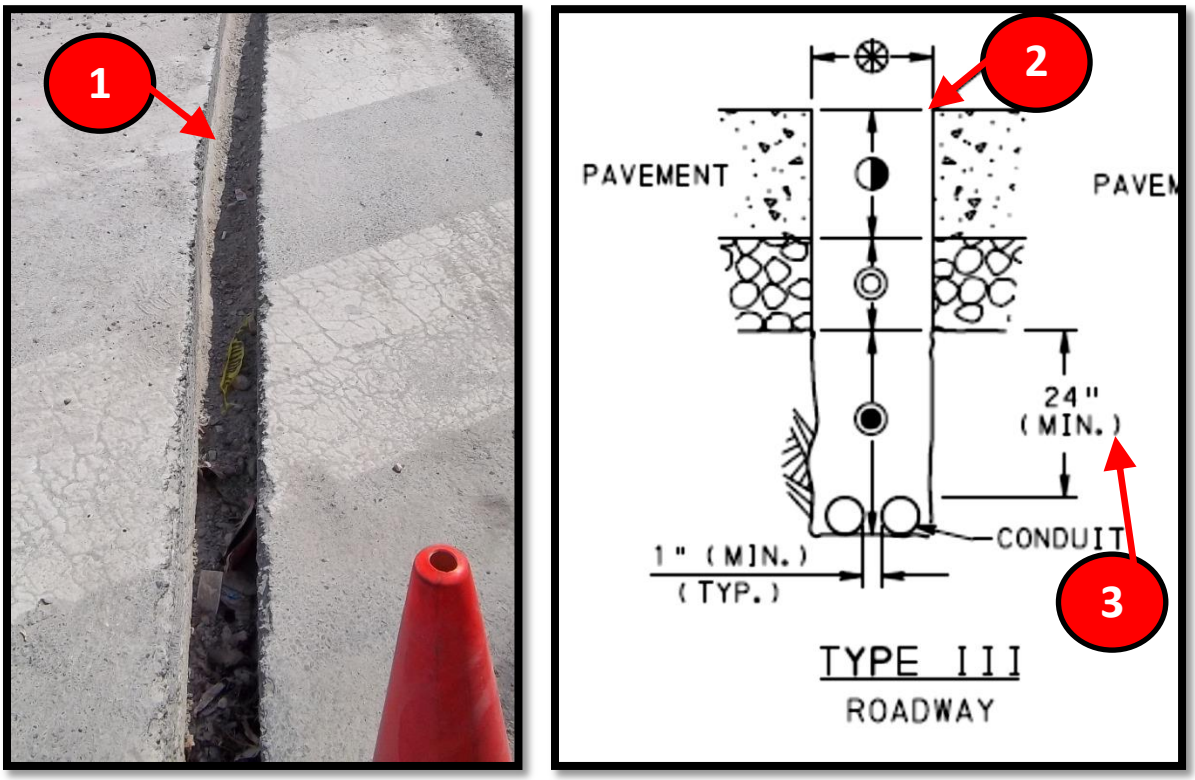


Trench and Backfill Type III (roadway)

TC-8804 Sheet 2 and Publication 408 Section 954.3

1. Verify the trench is wide enough to allow proper installation, backfill and compaction of the trench and that at least 1" can be maintained between each conduit and between the conduit and the edge of the trench.
2. Verify the surface on each side of the trench is saw-cut to a minimum depth of 3".
3. Verify the trench is deep enough to provide at least 24" of cover from the top of the conduit to the bottom of the sub-base.
4. Verify that bedding soil for the conduits has been placed at the bottom of the trench. Publication 408 Section 206.2(a)
5. Verify the contractor backfills the trench as soon as possible.
6. Verify that plastic marking tape is placed in the last layer of backfill material for the entire length of the trench. Publication 408 Section 910.3.(c)
7. Verify the sub-base is replaced as specified within the construction plans or as specified in Publication 408 Section 954.
8. Verify the trench is backfilled with Class A cement concrete up to the bottom of the existing sub-base.
9. Verify the pavement is restored as specified in Publication 408 Section 954.

Exhibit 6-18 Trench in Roadway (Type III)

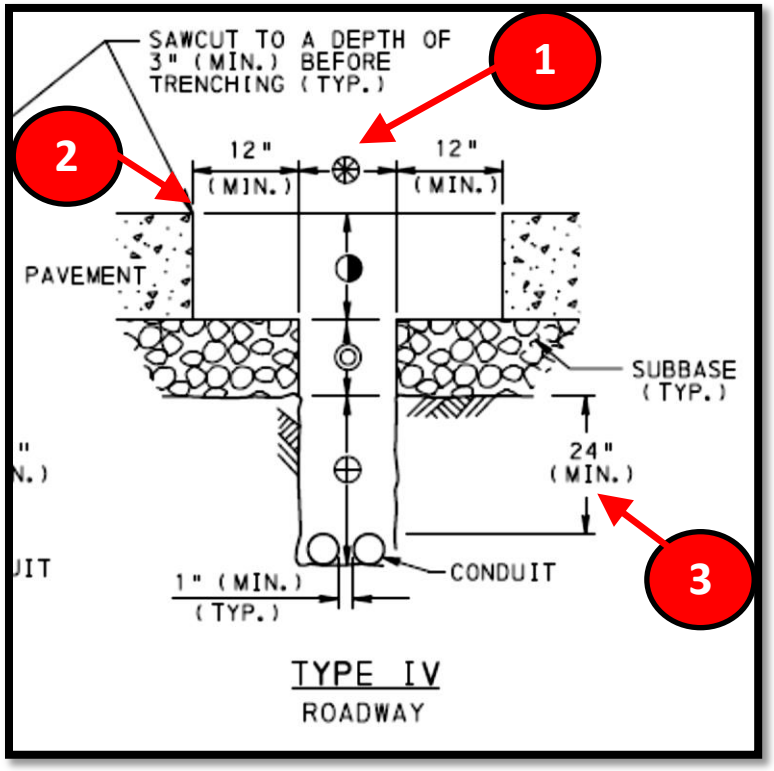


Trench and Backfill Type IV (Roadway)

TC-8804 Sheet 2 and Publication 408 Section 954.3

1. Verify the trench is wide enough to allow proper installation, backfill and compaction of the trench and that at least 1" can be maintained between each conduit and between the conduit and the edge of the trench.
2. Verify the surface on each side of the trench is saw-cut to a minimum depth of 3".
3. Verify the trench is deep enough to provide at least 24" of cover from the top of the conduit to the bottom of the sub-base.
4. Verify that bedding soil for the conduits has been placed at the bottom of the trench. Publication 408 Section 206.2(a)
5. Verify that plastic marking tape was placed within the last layer of backfill for the entire length of the trench. Publication 408 Section 910.3.
6. Verify the sub-base and pavement are both replaced as specified within the construction plans or as specified in Publication 408 Section 954.

Exhibit 6-19 Trench in Roadway (Type IV)



Trench and Backfill Directional Boring

Publication 408 Section 954.3(b)

1. Verify the contractor has the appropriate erosion and sedimentation control measures in place prior to boring.
2. Verify that boring pits are a minimum of 2' from the edge of roadway.
3. Verify that boring is below the existing roadway sub-base layer.
4. Verify that boring pits are covered with adequate protection if the drilling operation is left overnight.
5. Do not allow the use of pneumatic hammers.

Exhibit 6-20 Directional Boring

6.4.2 Conduit

Publication 408 Section 1101.09(a) & (b)

PVC (Polyvinyl Chloride)

Exhibit 6-21 PVC Conduit

1. Verify that all PVC conduit, conduit fittings, and conduit elbows are all supplied from the same manufacturer.
2. Verify the cement is labeled by or recommended by the conduit manufacturer.
3. Verify that expansion/ deflection fittings are provided for conduit mounted on or within structures. Standard Drawing BC 721M (BC -721)
4. Verify that conduit ends within junction boxes or foundations are restricted with a rodent-proof filler. Publication 408 Section 954.3(c)
5. Verify the conduit maintains at least 12” separation from other underground utilities. Publication 408 Section 954.3(c)
6. Verify that high-impact spacers are in place every 8’ on center if more than two rigid non-metallic conduits are installed in a common trench. Publication 408 Section 954.3(c)
7. Verify that underground conduits are at least 2” diameter unless otherwise specified. Publication 408 Section 910.3(g) & TC- 8804 Sheet 1
8. Verify that each conduit has a bell end or bushing to protect cables leaving the conduit.

Rigid Steel

Publication 408 Section 910.3(g)

Exhibit 6-22 Rigid Steel Conduit and Fittings

1. Verify the conduit is hot-dipped galvanized.
2. Thread steel conduit for couplings and fittings.
3. Verify that threads are coated prior to assembly.
4. Verify the contractor is using manufactured sweep bends, whenever possible.

6.4.3 Junction Boxes

TC-8804 Sheet 2

Exhibit 6-23 Junction Boxes

1. Verify dimensions of the junction box based on box type and approved CS 201 Form.
2. Verify there is a minimum of 2 cubic feet of coarse aggregate (#57 or #8) under all junction boxes.
3. Verify that Type JB-26 and JB-27 are not located in a vehicular traffic area.
4. Verify the rim of the box is 1" above final grade in earth or flush with final grade in paved surface areas.
5. Verify the lid is non-slip and is secured by a minimum of two corrosion resistant fasteners.
6. Verify that a water-tight connection to the housing is provided. Publication 408 Section 1104.05(c)
7. Verify the words "TRAFFIC SIGNAL" are imprinted on the lid. Publication 408 Section 1104.05(c)
8. Verify that cast iron or steel boxes have lids that are hot-dipped galvanized with a closed cell neoprene gasket. Verify that there is a factory-installed grounding stud and hex nut in rear of the box. Publication 408 Section 1101.10(a) & BC-721M
9. Verify that ground lugs are used to ground metal parts and that ground wires are not directly connected with the lid. RC- 81M & RC-82M
10. Verify the internal depth is in conformance with the depth specified for that type. TC-8804 Sheet 2
11. Verify that if the bottom is closed a 2" minimum drain hole is provided.

6.5 Controllers

Refer to Publication 408 Sections 952 and 1104.03 for further details.

6.5.1 Approval Listings

1. Verify the controller assembly is on the approved CS-201 Form.
2. Obtain documentation from the contractor verifying the controller assembly was shop (bench) tested.

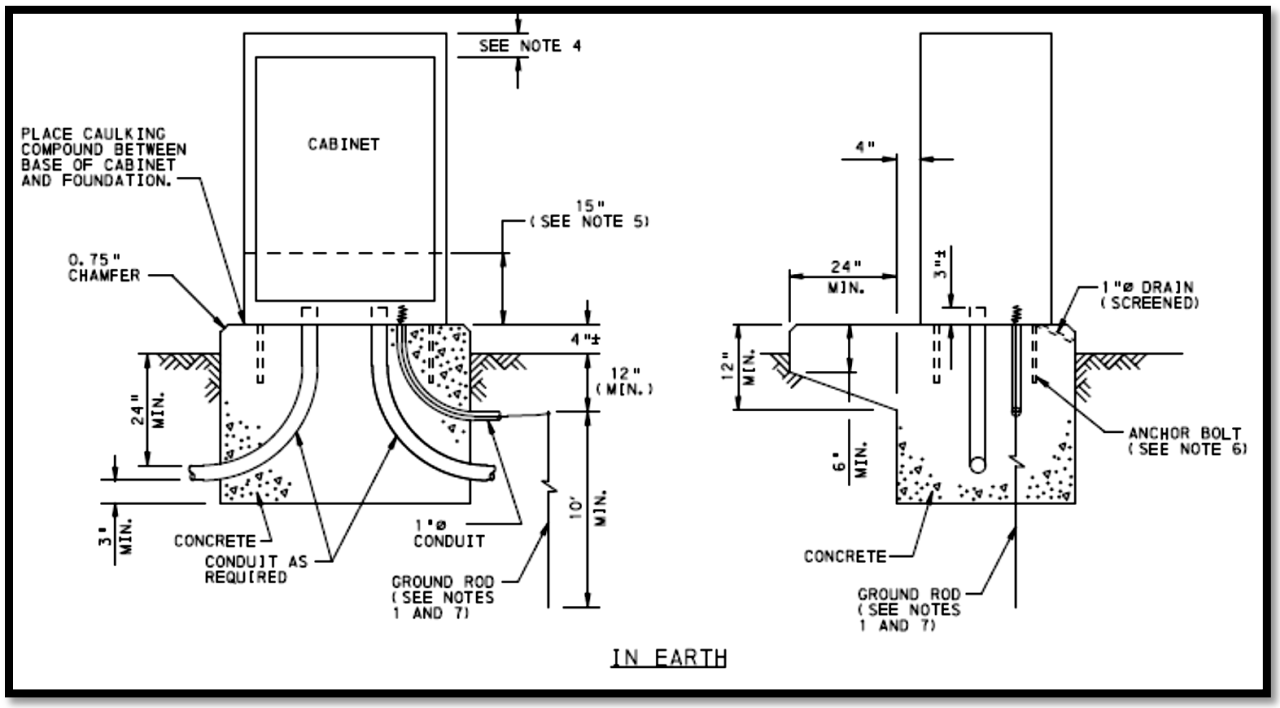
6.5.2 Controller Foundations (TC-8802)

In Earth

1. Verify the plans call for a base mounted (Type I mounting) controller assembly.
2. Verify the intersection and controller can be observed simultaneously from the proposed location prior to pouring the foundation.
3. Verify the foundation is 4" larger than the cabinet on all sides.
4. Verify the depth of the foundation is 31" plus the diameter of the largest conduit that runs through the foundation.
5. Verify the concrete pad in front of the controller extends 28" from the cabinet face with a depth tapering from 12" at the cabinet foundation to 6" at the front edge of the concrete pad.

6. Verify that there is a ¾" chamfer on all sides of the control cabinet foundation.
7. Verify the top of the control cabinet foundation is elevated 4" above the finish grade at its lowest point.
8. Verify that there will be no conflicts between conduits and the cabinet before constructing the foundation.
9. Verify that a 1" diameter screened drain pipe is installed from the bottom rear of the cabinet to the edge of the foundation, discharging above grade.
10. Verify the cabinet anchor bolts cast into the foundation are ½" x 12".
11. If anchor bolts are not used, verify that ½" x 3 ¾" expansion bolts are used.
12. Verify that caulking compound was applied around the entire cabinet enclosure between the base of the cabinet and the concrete foundation. Verify that caulking is in accordance with Publication 408 Section 705.8.

Exhibit 6-24 Controller Foundation in Earth

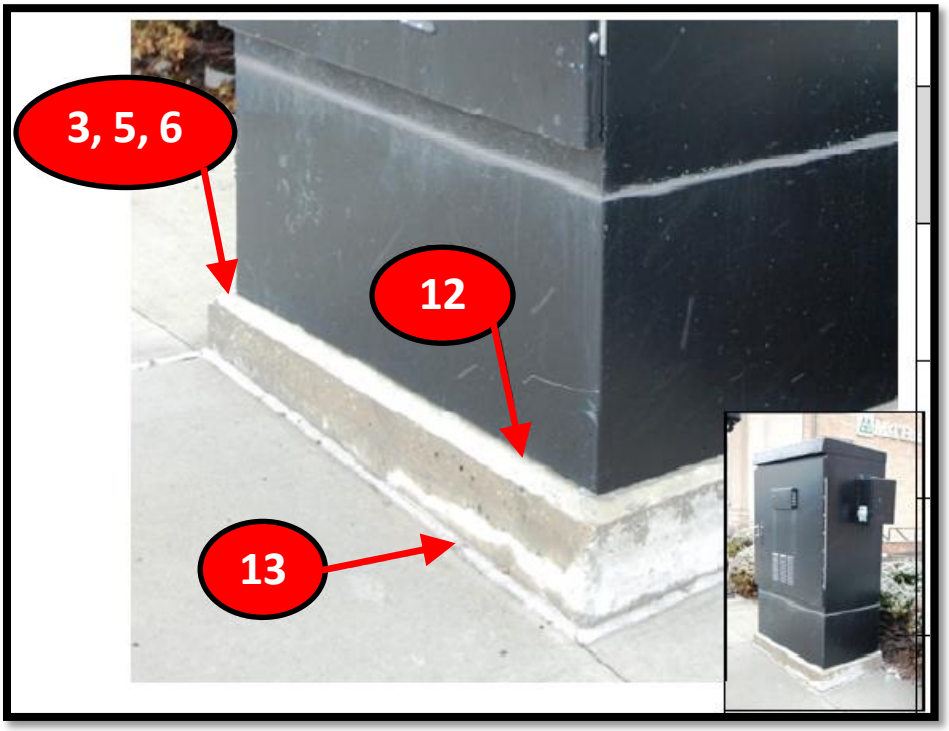


In Sidewalk or Paved Area

1. Verify the plans call for a base-mounted controller assembly (Type I mounting).
2. Verify the intersection and controller can be observed simultaneously from the proposed location and there is no undesirable door opening, such as opening into traffic, prior to pouring the foundation.
3. Verify the foundation is 4" larger than the cabinet on all sides.

4. Verify the depth of the foundation is 31" plus the diameter of the largest conduit that runs through the foundation.
5. Verify that there is a ¾" chamfer on all sides of the control cabinet foundation.
6. Verify the top of the control cabinet foundation is elevated 4" above the finish grade at its lowest point.
7. Verify that there will be no conflicts between the conduits and the cabinet before constructing the foundation.
8. Verify that conduits entering the cabinet are plugged with an approved duct seal formed around the wires to prevent entry from water, insects, snakes or rodents.
9. Verify that a 1" diameter screened drain pipe is installed from the bottom rear of the cabinet to the edge of the foundation, discharging above grade.
10. Verify the cabinet anchor bolts cast into the foundation are ½" x 12".
11. If anchor bolts are not used, verify that ½" x 3¾" expansion bolts are used.
12. Verify that caulking compound was applied around the entire cabinet enclosure between the base of the cabinet and the concrete foundation. Verify that caulking is in accordance with Publication 408 Section 705.8.
13. Verify that ½" pre-molded expansion joint filler was installed between the foundation and the surrounding paved area.

Exhibit 6-25 Controller in Paved Area

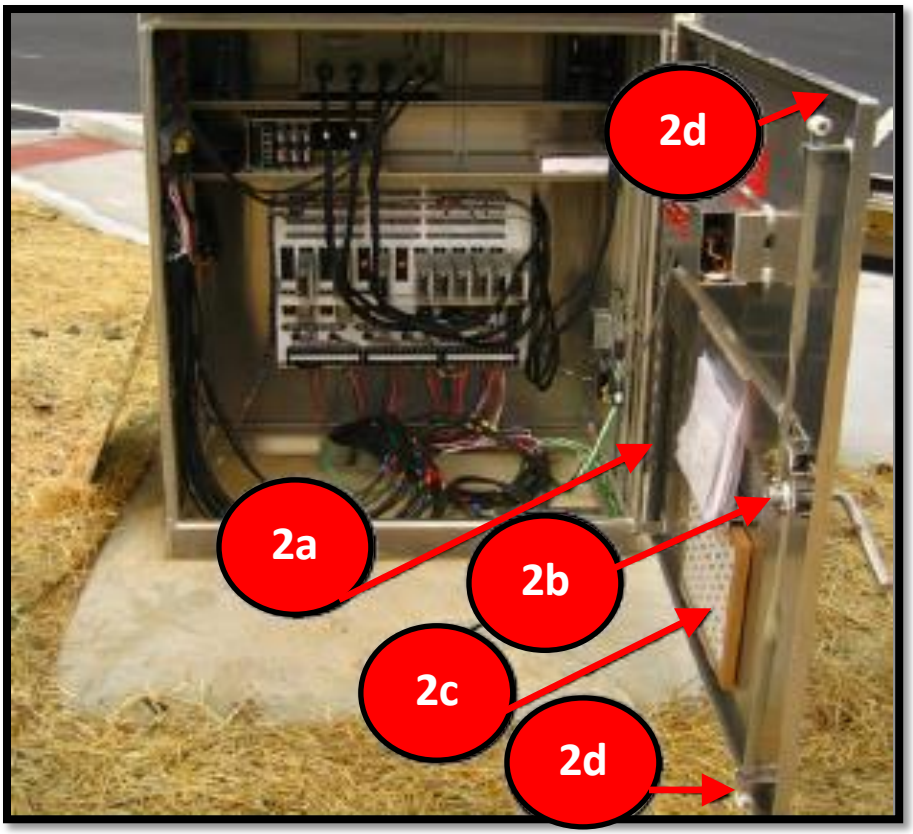


6.5.3 Controller Cabinets

Type I Mounting (Ground Mounted)

1. Verify the plans call for a base-mounted controller assembly (Type I mounting).
2. Verify the controller cabinet is equipped with the following items:
   - ✓ Full height continuously welded piano hinge. Type 170 - Publication 408 Section 1104.03 (b).2.f NEMA – Publication 408 Section 1104.03 (b)1.f.1
   - ✓ Key operated spring lock. Type 170 - Publication 408 Section 1104.03(b)2.f
   - ✓ Cover vents with full perimeter frame disposable filter securely held in place. NEMA – Publication 408 Section 1104.03(b)1.f.2
   - ✓ Three-point draw roller type door latching mechanism required. Type 170 - : Publication 408 Section 1104.03(b)2.f NEMA – : Publication 408 Section 1104.03(b)1.f.1
   - ✓ 15” minimum clearance between bottom of cabinet and the terminals, equipment, or devices. TC-8802
3. Verify that conduits entering the cabinet are plugged with an approved duct seal formed around the wires to prevent entry from water, insects, snakes or rodents.

Exhibit 6-26 Type I Ground Mounted Cabinet



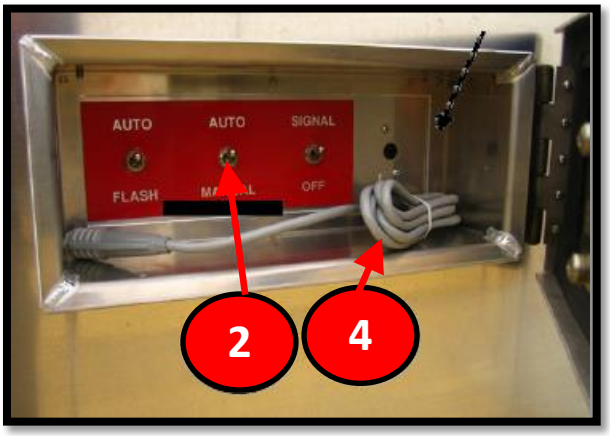
Type II Mounting (Pole Mounted)

1. Verify the plans call for a pole mounted controller assembly (Type II mounting).
2. Verify that there is no undesirable door opening, such as opening into traffic.
3. Verify the bottom of the cabinet is not higher than 27" when the cabinet extends over a sidewalk or walkway.
4. Verify the centerline of the cabinet is between 4'-3" and 4'-6" above final grade.
5. Verify that no portion of any equipment (except fan and light) is higher in the cabinet than the top of the door. TC-8802
6. Verify the door latching mechanism is a three-point draw roller type. Publication 408 Section 1104.03(b)
7. Verify that vents are covered with a full perimeter, framed, disposable, filter securely held in place. NEMA-: Publication 408 Section 1104.03(b).1.f.2
8. Verify that all terminals, equipment and devices are at least 3" above the bottom of cabinet. TC-8802

6.5.4 Manual Test Control

1. Review the requirements in Publication 408 for the type of controller:
   - ✓ Type 170 - Sections 1104.03 (b)2.b & 1104.03(b)2.f
   - ✓ NEMA - Section 1104.03(b)1.b
   - ✓ Type 2070 - Section 1104.03(b)3.b
2. Verify the manual control panel includes a method to switch the signal from automatic to manual control.
3. Verify the manual control panel is in a watertight enclosure compartment accessed separately from the main control cabinet and locked with a standard police key.
4. Verify the plug-in hand control cable is neatly tucked in the enclosure.

Exhibit 6-27 Controller Manual Test Control



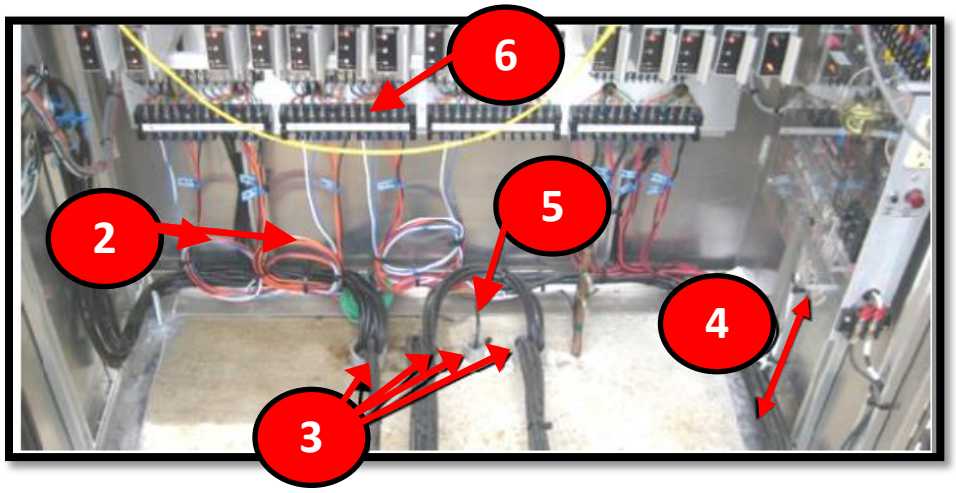
6.5.5 Grounding Assemblies

1. Verify that ground rods are copper clad steel, at least 5/8" diameter and at least 10' long. TC-8804
2. Verify that ground rods are connected to the grounding bus in the service disconnect and/or support with a #4 AWG (min) bare copper ground wire. TC-8804
3. Verify the ground wire is connected to the ground rod with either a bronze connector or an exothermic weld and the connection is coated with approved corrosion inhibitor. Publication 408 Section 1101.11(j) & TC-8802 & TC-8804
4. Note the ground rod is to be installed outside the foundation of the cabinet or support. TC-8804
5. Test in accordance with 910.3(q).

6.5.6 Control Equipment and Wiring Installation

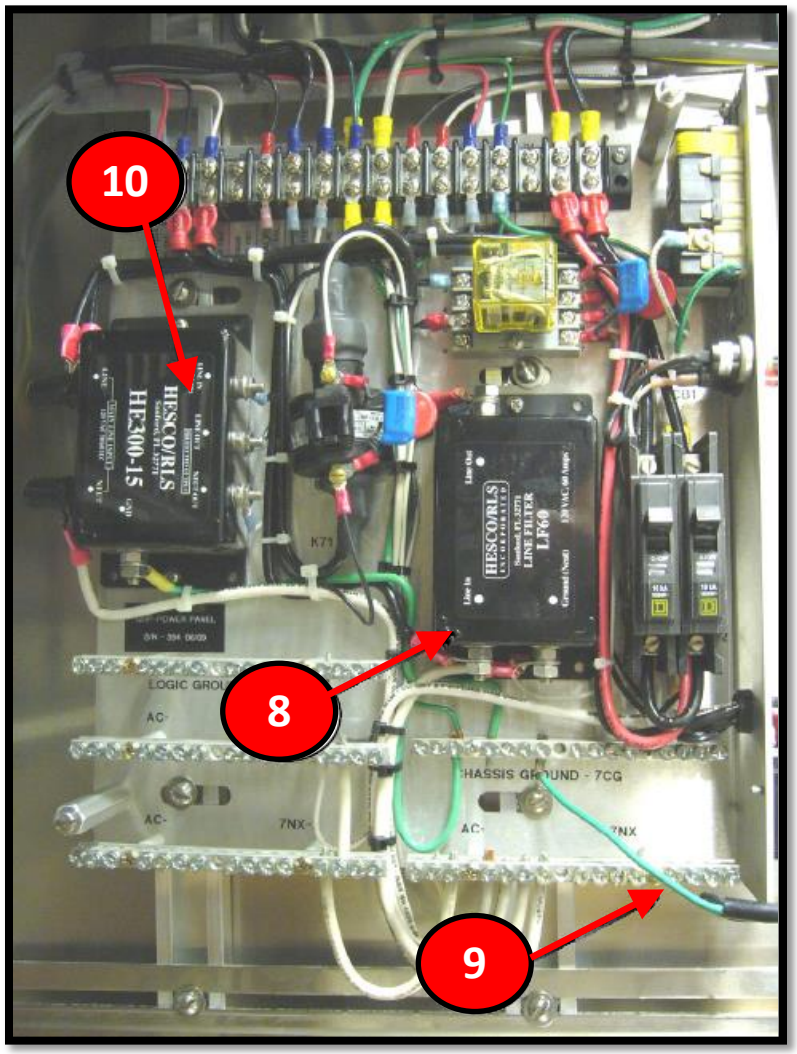
1. Verify the wiring and installation is done in a neat and workmanlike manner with all cables tie-wrapped. Publication 408 Section 952.3(d)1
2. Verify the spare conductors of signal cable and interconnection cable are neatly wrapped in the cabinet and are the same length as the active conductors. Publication 408 Section 952.3(d)1
3. Verify the conduit entry stubs are at least 3" high. TC- 8802
4. Verify there is a minimum of 15" between the bottom of the cabinet and terminals, equipment, and devices. TC-8802
5. Verify that a #8 AWG equipment grounding conductor is connected to the service disconnect. TC-8804
6. Verify there is only one conductor per screw on the terminal block or use pressure-type mechanical lugs for multiple conductors. Publication 408 Sect. 954.3(e)1

Exhibit 6-28 Control Equipment and Wiring Installation



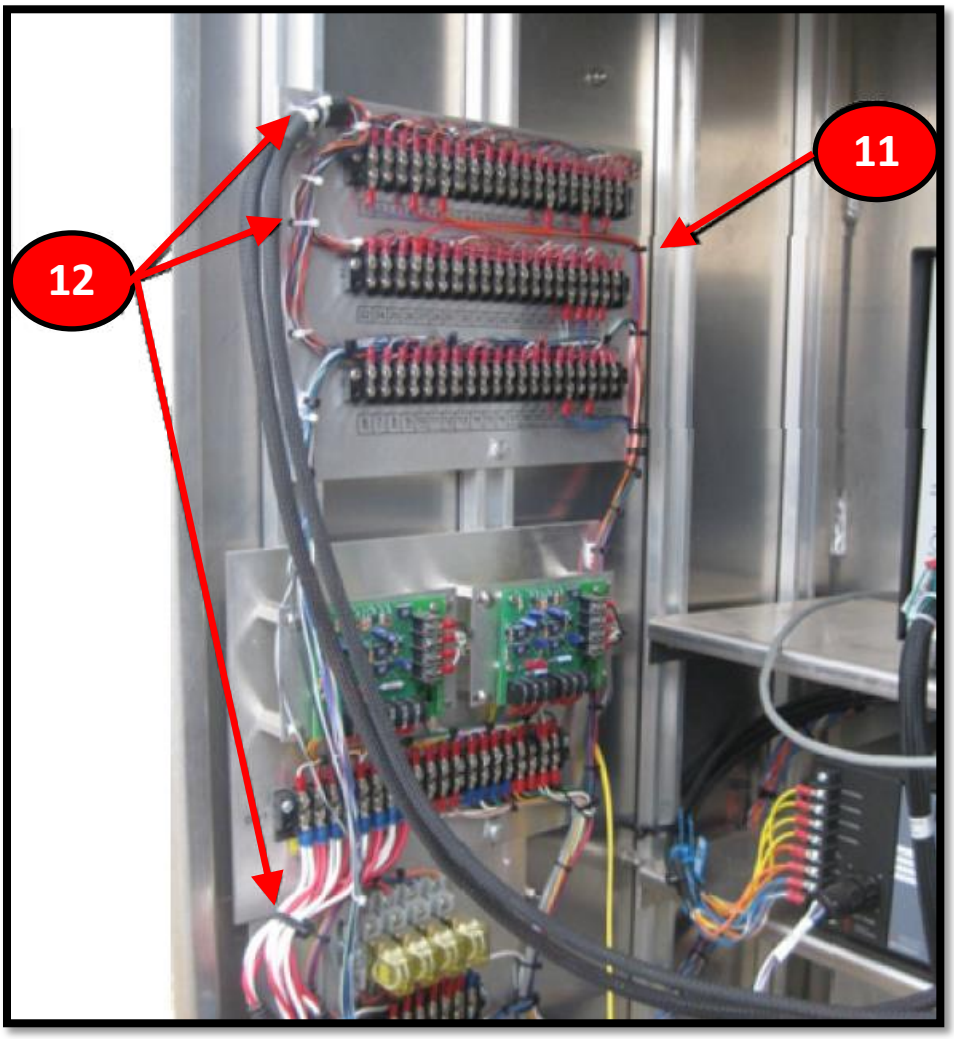
7. Verify the wiring and cables are neatly arranged and tiewrapped. Publication 408 Section 952.3(d)1
8. Verify that RFI Line Filter conforms to Publication 408 Section 1104.03 (c)3.b.
9. Verify the chassis ground bar is connected to the grounding system.
10. Verify the surge protection conforms to Publication 408 Section 1104.03(c)3.c.

Exhibit 6-29 Control Equipment and Wiring Installation



11. Verify that equipment is positioned in the cabinet so that all terminal strips are accessible without removing other equipment. Publication 408 Section 1104.03(b)2.f
12. Verify the wiring and installation is neat with all cables tie-wrapped. Publication 408 Section 952.3(d)1

Exhibit 6-30 Control Equipment and Wiring Installation



13. Verify that all grounding conductors have green insulation or are wrapped all the way around in green marking.
14. Verify that all neutral conductors have white insulation or are wrapped all the way around in white marking.
15. Verify that all wires are labeled with a unique wire or terminal number that indicates where it is to be connected.

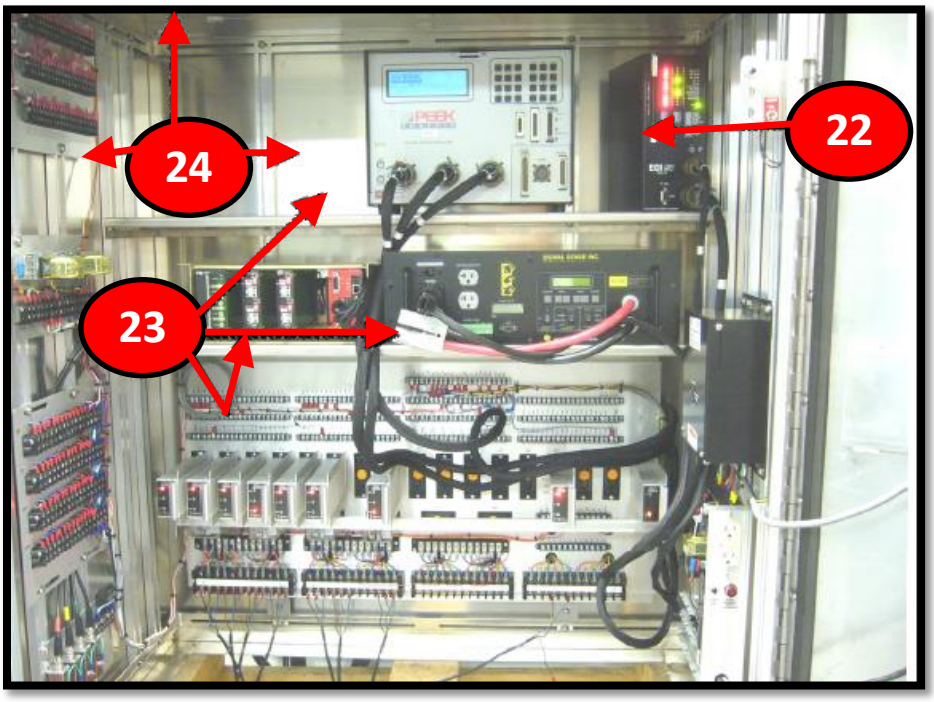
16. If specified, verify that access to the transfer switch and twist lock receptacle for connection to an emergency generator is installed behind a locked enclosure with police access. Publication 408 Section 1104.03(b)2.f
17. Verify there is a transfer switch relay to disconnect the permanent power source and connect the emergency power source. Publication 408 Section 1104.03(b)2.f
18. Verify there is a Ground Fault Circuit Interrupter (GFCI) protected convenience outlet on a dedicated 20 amp minimum circuit. Publication 408 Section 1104.5(j) and 1104.03(c)3.a

Exhibit 6-31 Control Equipment and Wiring Installation

19. If specified, verify there is a UPS/Battery back-up capable of a minimum four-hour back-up operation. Publication 408 Section 1104.05(i)
20. If specified, verify that a fiber optic patch panel is included.
21. If specified, verify that a fiber optic cable loop is included.

22. Verify that all equipment indicator lights are not blocked and can be seen from the cabinet doorway. Publication 408 Section 1104.03(b)2.f
23. Verify that all equipment is installed upright and on its own rack or shelf and not stacked on top of other equipment. Publication 408 Section 1104.03(b)2.f
24. Verify there is adequate room within the cabinet for equipment and servicing. Publication 408 Section 1104.03(b)2.f

Exhibit 6-32 Control Equipment and Wiring Installation



6.5.7 Programming and Timing

1. Verify with the District Signal Supervisor the timing plans and operation shown on the plan is correct and to be used at time of "turn on."
2. Verify the correct timing plans and operation shown have been programmed into the controller properly. Call the District Signal Supervisor, if required, to confirm correct programming.
3. With the contractor, observe controller operation with the traffic signals "off" to verify correct controller programming.

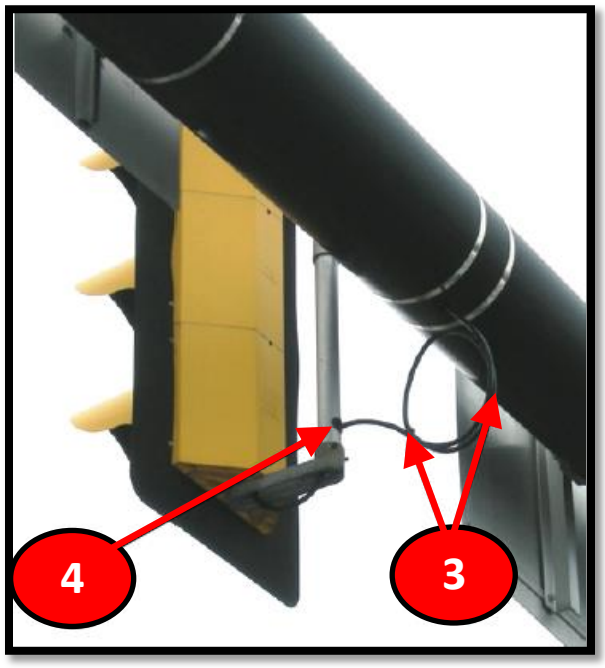
6.6 Signal Indications

Refer to Publication 408 Sections 955 and 1104.06 for further details.

6.6.1 Vehicular

1. Verify the signal housing and LED modules are the size and color specified on the traffic signal plan. Highway yellow is the standard signal housing color unless otherwise noted. Publication 408 Section 1106(a)1
2. Verify that overhead signals are installed with the top of the signal head at the same elevation prior to installing the tether wire. TC-8801 Sheet 2
3. Verify that drip loops at wire entrances to signal heads are secured with acceptable outdoor type cable ties. Publication 408 Section 954.3(e)1 & 1104.05(b)5
4. Verify there is a grommet at the wire entrance to the mounting bracket. TC-8801 Sheet 1

Exhibit 6-33 Vehicular Traffic Signal Indications



5. If optically programmed signal heads are specified, verify the contractor coordinates the field programming of the signal heads with the District Signal Supervisor for cut-off and distance limiting.
6. Verify the specific locations of overhead vehicular signal heads are as shown on the traffic signal permit plan.
7. Verify the vehicular signal heads are generally aimed at approaching traffic that is 150’ in front of the stop line.

8. Verify mounting hardware which includes:
   - ✓ Span wire hanger (span wire installations)
   - ✓ Balance adjuster
   - ✓ Cable entrance fitting (mast arm installations)
   - ✓ Pipe, as required, to keep the tops of all signal heads at the same elevation.

Exhibit 6-34 Vehicular Traffic Signal Indications

9. Verify that cable entrance fitting is positioned so the cable entrance will be from the backside of the signal housing.
10. Verify the visors, louvers and back plates indicated on the plan or in the specifications have been installed properly.
11. Verify there is 15’ to 19’ of vertical clearance for overhead signal housings, unless otherwise specified on the traffic signal permit plan.
12. Verify the minimum clearance as indicated in Publication 149 is obtained from curb or edge of shoulder to the post-mounted signal housings. TC-8801

6.6.2 Pedestrian

Exhibit 6-35 Pedestrian Indications

1. Verify the type of pedestrian signal head housing and LED Modual (Type A or Type B) is as called for on the plan.
2. Verify the signal housing is the color specified on the plan or in the specifications. Highway yellow is the standard color unless otherwise noted. Publication 408 Section 1106(a)1
3. Verify the signal housing is constructed of aluminum or polycarbonate resin. The contractor has the option to provide either unless otherwise specified. Publication 408 Section 1106(a)1
4. Verify the minimum clearance as indicated in Publication 149 is obtained from curb or edge of shoulder to the post-mounted signal housing. TC-8801
5. Verify the bottom of the signal head is between 7’ and 10’ above the sidewalk. If there is no sidewalk, verify the bottom of the signal head is between 7’ and 10’ above the pavement grade at the centerline of the road. TC-8801

6.6.3 Preemption Fail Safe Indications

1. Verify that emergency vehicle preemption is specified and shown in the movement phase diagram.
2. Verify the size and color of the confirmation light supplied by the contractor is in accordance with the specifications. Coordinate with the District Signal Supervisor and the municipality.
3. At signals with emergency vehicle preemption on intersecting approaches, verify that confirmation lights are associated with the proper approach.
4. Verify that pre-empt receivers are mounted in the right location and pointed in the correct direction.

6.7 Electrical Distribution

Refer to Publication 408 Sections 954 and 1104.05 for further details.

6.7.1 Grounding

Publication 408 Section 954.3(d) and Section 1104.03(d)

1. Verify that a continuous mechanical and electrical grounding system exists connecting the following items:
   - ✓ Service disconnect enclosure
   - ✓ Controller assembly and cabinet
   - ✓ Traffic signal supports
   - ✓ Ground rods
   - ✓ Span wires
   - ✓ Tether wires
   - ✓ Steel conduit
   - ✓ Metallic junction boxes
2. Verify that Underwriter's Laboratory listed bonding/grounding bushings are installed on the ends of all steel conduits and the bushings are connected to the grounding system.

6.7.2 Signal Cable, Wiring and ID Tags

1. Verify that all signal cable, wiring and ancillary equipment are included on the CS-201 Form.
2. Verify that lubricant is used to install cable in the conduit. If new cable is installed in existing conduit, verify the conduit was cleaned in accordance with Publication 408 Section 910.3.
3. Verify that signal wires and cables are spliced only in pole bases using waterproof resin-filled wire nuts.
4. Verify that ground wires are spliced only in junction boxes.
5. Verify that all cables at splices in pole bases or cabinets are properly labeled or have ID tags attached.
6. Verify that all terminal connections have been banded and the appropriate coding used in accordance with Publication 408 Section 954.3.
7. Verify that all spare and unused conductors have been terminated on the ground buss.
8. Verify that enough signal cable slack is left for proper wiring connections and drip loops.
9. For span wire installations, verify the cable is lashed to the span wire in accordance with TC-8801.
10. Verify that drip loops have been included in all signal cables entering signal head housings. Verify the cable enters the signal head housing at an upward angle to prevent water from entering the signal head. Verify the drip loops are secured with outdoor-type, self-locking cable ties. TC-8801

6.7.3 Wiring Diagrams

Publication 408 Section 1104.01(d)

1. Verify the contractor provides three copies of the cabinet wiring diagram and manufacturer's timing plan for each controller assembly. If there are changes to the timing plan during testing, three new sets of timing plans are required.

6.7.4 Testing

1. Verify the contractor certifies all equipment and material has been checked and is in operating order prior to it being energized.
2. Verify and document the faulty or defective material that was removed and replaced to correct the condition that halted the test.
3. Test grounding system in accordance with Publication 408 Section 910.3 (q).

6.8 Detection

Refer to Publication 408 Sections 956 and 1104.07 for further details.

6.8.1 Vehicular

Inductance Loops - Cutting, Placing Wire and Sealing

1. Inspector In-Charge determines in which paving layer (wearing course, base course or "pre-formed" under new concrete pavement) the plans or specifications call for the loop sensor to be installed.
2. Verify that sensors are located as indicated on the plan. Verify the saw-cutting will not go through pavement joints or areas of deteriorating pavement. Contact the District Signal Supervisor if there are any questions prior to installing loops.
3. Verify the loop layout is in accordance with TC-8806 and the saw cut depth is constant for the entire loop sensor.
4. Verify the slot is cleaned of moisture and debris, preferably with a compressed air hose.
5. Verify the loop sensor wire is #14 AWG, IMSA Specification 51-5. It is an insulated wire inside a PVC tube. Publication 408 Section 1104.07(b)1.a.
6. Verify that each saw cut slot has the required number of turns of sensor wire per detector as required to provide the specified inductance.
7. Verify that all wires in a common slot are proceeding in the same direction.
8. Verify the sensor wire is tamped into the slot with a nonmetallic tool.
9. Verify the saw cut ends one foot (1') from the edge of pavement and a rotary drill is used to make a hole in the pavement. Verify the sensor wire is installed through conduit to the junction box by trenching through either the shoulder or sidewalk.
10. Verify the splice of the sensor wire to the lead-in wire is made only inside the junction box. Verify there is no other splicing of sensor wire. TC¬8806.
11. Verify the ends of the conduit are properly sealed with duct seal after the sensor wire is installed. TC-8806.
12. Verify the amplifiers are on the approved CS-201 Form.
13. Verify the values of the tests of the sensor after installation for leakage resistance, series resistance, and inductance before sealing the saw cut slot. Publication 408 Section 956.03(a)1 Cutting, Placing Wire and Sealing
14. Verify the sealant used to seal the saw cut is in Bulletin 15 and the manufacturer's specifications for mixing and installation are followed. Verify the sealant is not placed when the temperature is under 32° F or during precipitation. Publication 408 Section 956.03(a)1
15. Verify the slot is filled to within 1/8" of the pavement surface.
16. Verify the excess sealant is removed, but not with the use of solvents. Do not allow traffic on the sealant until it is properly cured.

17. Verify that location of the sensor wire is marked after installation to ensure that core samples do not sever the wire.
    - ✓ Verify that all excess loop sensor wire or lead-in wire is banded in the junction box to prevent movement which will result in false calls.
    - ✓ Verify after testing inductance, a copy of the inductance readings is placed, along with the make and model number of the testing equipment, in the controller cabinet.

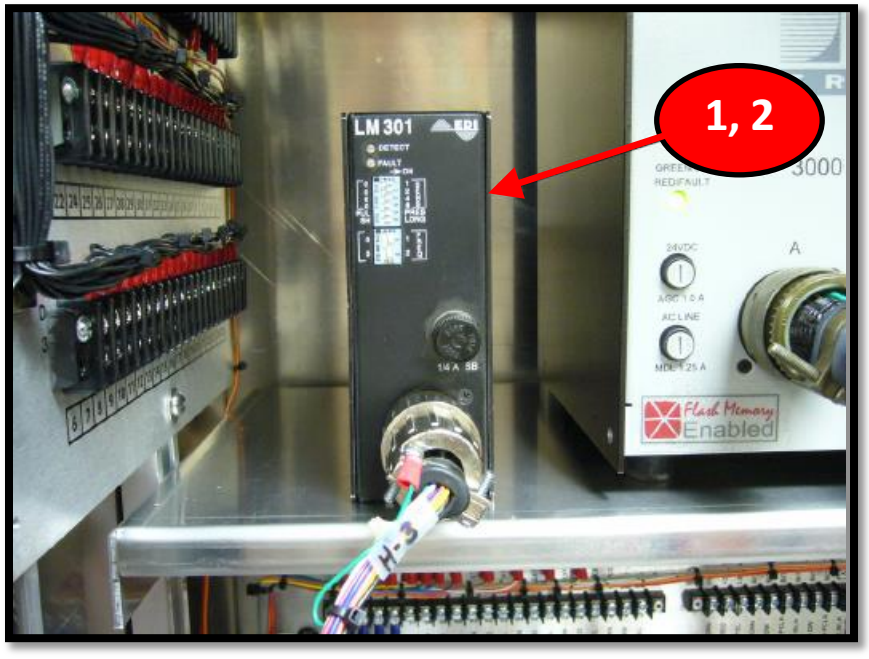
Lead-in Cable and Splicing

1. Verify that detector lead-in cable is #14 AWG, IMSA Specification 50-2. Publication 408 Section 1104.07(a)2
2. Verify the detector lead-in cable is installed in one continuous length to the terminal strip in the controller cabinet. No splices are allowed in the lead-in cable.
3. Verify the detector lead-in cable is spliced to the sensor wires as shown in TC-8806 or by using another approved method.

Amplifiers

1. Verify that after connecting to the loop amplifier, the amplifier has been adjusted as per the manufacturer's instructions to obtain the necessary sensitivity. Verify that no "false" calls are being placed by traffic moving in the opposite direction.
2. Verify the loop amplifiers are labeled with the correct phase and movement.

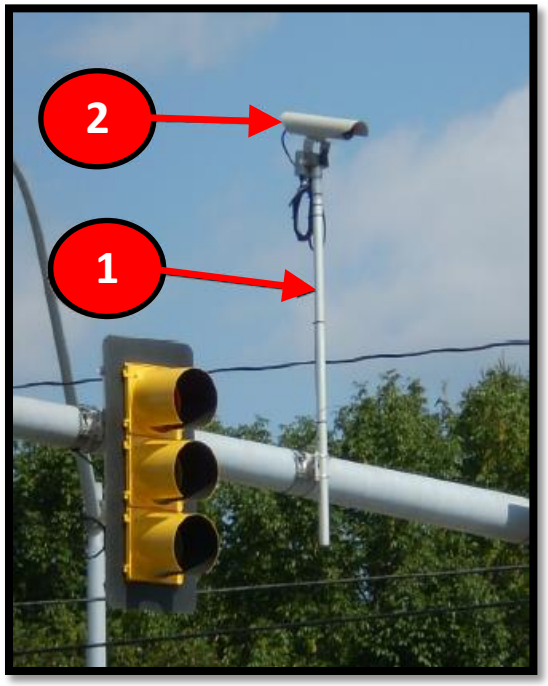
Exhibit 6-36 Detector Amplifier



Video Detection

1. Verify the video detection camera is mounted at the highest point possible.
2. Verify that each camera is provided with a sun shield.
3. Verify that all cables and connections are per the manufacturer's specifications.
4. Verify that each zone of video detection on the plans is covered by the system.

Exhibit 6-37 Video Detection



Microwave Radar, Digital Wave Radar, Magnetic and Magnetometer Detection Systems

1. Verify which type of detection system is specified. Coordinate with the District Traffic Signal Supervisor for the location and detection zone coverage.
2. Verify that all installation, cable and connections are per the manufacturer's specifications.

6.8.2 Pedestrian Pushbuttons

1. Verify whether a standard pushbutton and sign or an accessible pedestrian signal and related equipment is called for on the plans or specifications.

Standard Pushbutton

1. Verify the pedestrian pushbutton is installed so the centerline of the pushbutton is between 40" to 44" above the top of the foundation.
2. Verify the pedestrian pushbuttons are at least 2" in diameter.
3. Verify that pushbuttons are located as per the plan. Coordinate with the District Signal Supervisor regarding any changes or questions prior to installation. TC-8803
4. Verify that vandal-proof (difficult to remove without special tools) stainless steel hardware is used to attach the pushbutton to the support.
5. Verify the hole in the support was de-burred after drilling but prior to cable installation.
6. Verify that sealant was placed at the top of the pushbutton where it contacts the support.
7. Verify by field test that the proper phase and timing is called when the pushbutton is actuated.

Exhibit 6-38 Standard Push Button

Accessible Pedestrian Signal

1. Verify the pedestrian pushbuttons are at least 2" in diameter.
2. Verify that pushbuttons are located as per the plan. Coordinate with the District Signal Supervisor regarding any changes or questions prior to installation. TC-8803
3. Verify that vandal-proof (difficult to remove without special tools) stainless steel hardware was used to attach the pushbutton to the support.
4. Verify the hole in the support was de-burred after drilling but prior to cable installation.
5. Verify that pushbutton, speaker and vibrotactile device are attached to the support with the proper orientation to the applicable crosswalk. Verify that speakers are not attached to pedestrian indications.
6. Verify that sealant was placed at the top of the pushbutton, speaker and vibrotactile device where they contact the support.
7. Coordinate with the District Traffic Signal Supervisor to verify the types of audio messages to be used.
8. Verify by field test the proper phase, audio messages and timing are called when actuated.
9. Verify the message displayed/operations of accessible pedestrian signals when emergency vehicle preemption is invoked.
10. If volume of pedestrian signals does not self-adjust to ambient noise, manual adjustments will be required.

6.8.3 Preemption Systems

1. Verify which type of preemption system is required by the plans and specifications
   - ✓ Audio,
   - ✓ Optical, or
   - ✓ Global Positioning Satellite (GPS)
2. Verify the detector/receiver location prior to installation. A minimum distance of 500' away from the stop bar on the appropriate approach is recommended for a detection of an actuating vehicle.
3. Verify that any training requirements called for in the specifications are followed and that appropriate personnel are trained.
4. If there are issues with detection, work with vendor to test emergency vehicle sirens/emitters to confirm vehicles meet specifications.
5. If possible, it is desirable to test the preemption system with the municipality's actual responding units.

6.8.4 Other Preemption Systems

1. Seek guidance from the Distric Traffic Signal Supervisor when railroad preemption or other complex signal operations are indicated.

6.9 Pavement Markings and Signs

6.9.1 Pavement Marking Locations

1. Verify the location of crosswalks and stop lines with the District Traffic Signal Supervisor prior to placement.
2. Verify coordination of pavement marking and detection zone locations.

Exhibit 6-39 Pavement Markings

6.9.2 Placement of Pavement Marking Material

1. Verify the type of pavement marking material called for in the plan is applied in the field.
2. Coordinate the application of the pavement marking material with the contractor to ensure the material is applied at the correct time in the project progress and the weather and pavement conditions are in accordance with the manufacturer's specifications.

Exhibit 6-40 Placement of Pavement Markings

6.9.3 Sign Types and Locations

1. Verify the type of sign installation and location with the District Signal Supervisor prior to installation. PUB 111M
2. Verify the signs provided are from an approved sign manufacturer and the supplier's PennDOT identification number is on the back of each sign.
3. Verify the date of installation is placed on the back of the sign with a permanent marker.
4. Verify the faces of new signs are covered until project conditions are appropriate for their display.

Exhibit 6-41 Traffic Signs

6.10 Traffic Signal Systems

Refer to Publication 408 Sections 953 and 1104.04 for further details.

6.10.1 Equipment

1. Verify the location of the master controller, master coordinating unit, or server matches the plans.
2. Verify the required arrangements have been made with the municipality and the utility that will provide the communications connection.

6.10.2 Software

1. Verify the installation of the proper number of traffic signal system software packages, typically two: one package on a designated municipal computer and the other package on a designated Department computer. Publication 408 Section 953.3(d)1
2. Verify that all project-specific intersection graphics, intersection data, overall system mapping, timing plans and other software programming has been completed. Publication 408 Section 953.3(d)2

6.10.3 Training

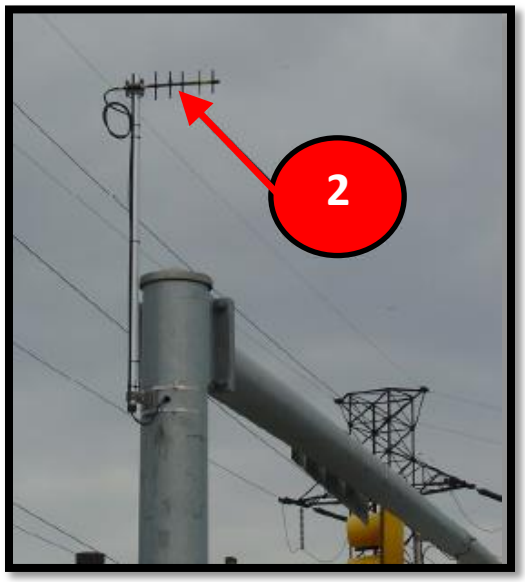
1. Verify the proper amount of training on the traffic signal system software has been completed. Amount of time varies by project. Coordinate with the District Signal Supervisor. Publication 408 Section 953.3(d)3

6.10.4 Communications

Radio Publication 408 Section 953.3(e)

1. Verify the appropriate radio units are installed at the master controller and the local controllers and that each radio unit has repeater capability.
2. Verify the correct type of antenna is installed at each intersection as per the plan and the antenna is pointed in the correct direction.

Exhibit 6-42 Communications - Antenna



3. Verify that all coaxial cable and antennas are grounded properly and that lightning surge suppressors are installed correctly.
4. Verify the contractor monitors the radio communication system tests to evaluate and adjust the radio system before use.
5. Verify the contractor provides all warranties and product information from the contractor for all installed equipment.

Cable Publication 408 Section 953.3(g)

1. Verify that all equipment, control cable and communication cable have been installed per the manufacturer's requirements.
2. Verify that all cables are terminated on an approved terminal strip and do not have any splices.
3. Verify the lightning and surge suppression equipment has been installed as specified.
4. Verify the Contractor provides all warranties and product information from the contractor for all installed equipment.

Cellular Publication 408 Section 953.3(h)

1. Verify the cellular modem has been installed at the master controller and the local controllers.
2. Verify the correct type of antenna is installed at each intersection and the size matches the modem to be used.
3. Verify that surge protection for the cellular modem is in place and is properly grounded.
4. Verify the Contractor provides all warranties and product information from the contractor for all installed equipment.

Telephone Dialup Publication 408 Section 953.3(i)

1. Verify the dialup modem has been installed at the location as shown on the plans.
2. Verify that surge protection for the dialup modem is in place and properly grounded.
3. Verify the Contractor provides all warranties and product information from the contractor for all installed equipment.

Fiber Optic Cable Publication 408 Section 953.3(j)

1. Verify that a fiber optic network switch has been installed at the master controller and the local controllers.
2. Verify that fiber optic cable has been installed between each controller location as shown on the plans.
3. Verify that a fiber optic patch panel has been installed in each controller cabinet.
4. Verify the pulling strength and minimum bending radius of the fiber optic cable have not been exceeded.
5. Verify the contractor monitors all fiber optic performance tests and verify that they are completed with acceptable results. Document the results as specified.
6. Verify the contractor provides all warranties and product information from the contractor for all installed equipment.

6.10.5 Testing

See Section 6.11 of this training manual for details.

6.11 Final Inspection and Testing

6.11.1 Inspection, Turn-on Procedures and Flashing Operation (if required)

1. After the contractor indicates that a traffic signal installation is ready to be energized and all functional testing (including conflict monitor testing, preemption testing and communication testing) is completed and documented, contact the District Signal Supervisor to schedule a final review and "turn-on." Correct any deficiencies found and timing plan changes prior to the "turn on." Newly signalized intersections will be put in the "flashing" mode as directed by the District Signal Supervisor.
2. Notify the appropriate municipal personnel to attend the "turn on" and operational testing. Coordinate with the District Signal Supervisor.

6.11.2 30-Day Test

1. With the signal in full operation, monitor the 24-hour operating test for not less than 30 consecutive calendar days. Direct the contractor to correct any failure caused by malfunctioning parts or equipment, or faulty workmanship. The contractor should correct the condition in less than 24 hours after notification. Publication 408, Section 1104.01(g)1
2. Energy costs are the responsibility of the contractor during the test period.
3. After any failure caused by malfunctioning parts or equipment, or faulty workmanship, is corrected, the 30-day operating test begins anew. The District Signal Supervisor shall be notified of failure and the restart of the new testing period. There is no time limit for how long the testing period may last if failures continue to occur. With the correction of each failure, the 30-day test period begins again. The signal must operate correctly for 30 consecutive days for the test to be satisfactorily completed.

6.11.3 180-day Equipment Guarantee Period: (Publication 408 Section 1104.01(g)2)

1. After the 30-day test is satisfactorily completed, the 180-day equipment guarantee period begins. The in-service operation of mechanical and electrical equipment, the controller assembly and related components are included in the 180-day guarantee period. On HOP projects, it is the responsibility of the municipality to coordinate with the contractor for guarantee issues.
2. During this period the contractor has the following responsibilities:
   - ✓ Maintain equipment in the controller cabinet. Use additional locks, as necessary, to prevent entry by others.
   - ✓ Repair faulty workmanship, repair or replace defective materials or equipment, and correct malfunctions in the controller cabinet within 48 hours of commencing repairs.
   - ✓ Commence repairs no later than the working day following notification of failures or malfunctions.
   - ✓ Guarantee repairs or replacements for 30 days or the balance of the 180-day guarantee period, whichever is longer.

6.11.4 Systems Testing

Publication 408 Section 953.3(d)1 and Section 953.3(d)2

1. Verify that all software packages are in place and functional at the specified municipal location and/or Department computer.
2. After the successful completion of the 30-day test at every individual intersection, a separate 30-day operations test on the traffic signal system and the related communications system can begin. This 30-day test is separate and distinct from the 30-day test for each individual intersection.
3. With the signal system in full operation, monitor the 24-hour operating test for not less than 30 consecutive calendar days. Direct the contractor to correct any failure caused by malfunctioning parts or equipment, software, or faulty workmanship. The contactor should correct the condition in less than 24 hours after notification.
4. After any failure caused by malfunctioning parts or equipment, software, or faulty workmanship is corrected, the 30-day operating test begins anew. There is no time limit for how long the testing period may last if failures continue to occur. With the correction of each failure, the 30-day test period begins again. The signal system must operate correctly for 30 consecutive days for the test to be satisfactorily completed.

6.11.5 Operation Validation

During this period, the 30-day testing period occurs. As required, fine tuning of the operation and/or design will occur. All design package submissions are updated and As-Built (Record) plans are submitted. Upon completion of the 30-day test, a 180-day warranty period begins for the contractor to guarantee the in-service operation of mechanical and electrical equipment, related components, and the controller assembly.

6.12 Traffic Signal Inspection Form

Handout – Traffic Signal Inspection Form

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