

SECTION 2

2.0 TRAFFIC SIGNAL DESIGN GUIDELINES

2.1 SIGNAL DESIGN ELEMENTS

Any traffic signal proposed for installation on City streets shall meet the minimum criteria as outlined in the *Manual on Uniform Traffic Control Devices (MUTCD)* and the Alabama Department of Transportation (ALDOT) *Traffic Signal Design Guide & Timing Manual*, latest editions. Additionally, traffic signals proposed for installation on City streets may only be considered at locations where their spacing from existing signals would not deteriorate roadway capacity along the street. A request for traffic signalization shall address the minimum criteria for installation as well as the roadway capacity impacts created by signal spacing. A development may be responsible for all or part of any right-of-way, design, hardware, and construction costs of a traffic signal if it is determined that the signal is warranted by the traffic generated from the development. The procedures for traffic signal installation shall be in accordance with criteria established by the MUTCD and ALDOT, as applicable.

2.1.1 Signal Heads

All signal lenses shall be DIALIGHT (or approved equal) twelve (12) inch LED balls with a quick disconnect feature utilizing a fork terminal end for termination purposes. The LED lenses shall be wired to a terminal block located in the yellow lens housing. The LED lenses shall be installed in a yellow aluminum signal head housing with yellow aluminum tunnel visors. Back plates are typically not required on City signals unless a visibility problem exists. Back plates are required by ALDOT on all State routes. All mounting hardware for mast arm traffic signals shall be black Pelco articulating cable mount brackets. All mounting hardware for span wire traffic signals shall be aluminum tri-stud hanger assemblies. Signal wire for mast arm intersections shall enter through the bracket and not be externally exposed.

Signal head placement shall adhere to the standards set forth in the MUTCD, latest edition. A minimum of two (2) signal faces shall be provided for the major movement on each approach, even if the major movement is a turning movement. If the signal faces provided on the mast arm or span wire are more than one hundred eighty (180) feet beyond the stop line, a supplemental near side signal face shall be installed as required by the MUTCD. Where dual left turn lanes are provided, a separate left turn face shall be provided for each lane.

Lateral positioning of signal heads shall be in accordance with the guidelines established in the latest edition of the MUTCD. Adjacent signal faces on the same mast arm or span wire shall be placed no closer than eight (8) feet apart. The placement of the signal head over the roadway shall be such as to provide a minimum seventeen (17) foot vertical clearance from the bottom of the signal head to the roadway.

2.1.2 Signal Supports

All signal supports shall be decorative mast arms unless approved by the City Engineer. All mast arm signal poles shall be smooth, round poles with an arched mast arm and a powder

coated gloss black (P-33) finish. Poles are to be assembled with the ornamental pole base and ornamental pole top per the City standards. The factory finish on the ornamental ball on pole top shall be gloss black on all assemblies.

Strain poles and mast arm poles should be located as far as practical off the edge of roadway while staying within the right-of-way. Additionally, the poles shall be located to maximize the separation between the foundation and existing utilities. The location of strain poles and mast arm poles shall be in compliance with the AASHTO *Roadside Design Guide* and ALDOT standards, and approved by the City Engineer.

2.1.3 Cabinet and Controller Equipment

The standard controller to be used at all signalized intersections shall be an Eagle or approved equal 16-phase, NEMA-compatible controller that meets current ALDOT standards and specifications. The controller shall be capable of internally remapping outputs to facilitate FYA operation in both standard and compact modes. Controller cabinets shall be 16-phase powder coated gloss black ground mounted cabinets with railroad preemption and remote traffic signal override cord, unless otherwise approved by the City Engineer. The controller cabinet shall be so oriented that the traffic personnel will be facing the intersection while looking in the cabinet. Controller cabinets should be located as far as practical off the edge of the roadway and in the same intersection quadrant as the power source. Cabinet shall have integrated UPS cabinet unless approved by Traffic Engineer. All cabinet components and controller shall be capable of operation with flashing yellow arrow sequencing. All cabinet pedestals shall be constructed with a spare 2" conduit stubbed out for future use.

All new cabinet facilities, including upgrades to existing locations, shall be equipped with status monitoring through the Glance service from Applied Information. As applicable to the location or if specified by the Traffic Engineer, this may also require additional Glance features, including Preemption and Data Pass-through (Controller communications, Video, MMU).

2.1.4 Communications

Signal interconnect provides communication between two (2) or more individual traffic signals to provide coordination of signals. Legacy communication types at existing locations include hardwire, twisted pair, closed-loop and serial radio. New installations shall use Cellular or fiber Ethernet to provide communications for controllers and for other network-capable devices in each location. Other types of communication may be considered and approved at the discretion of the City Engineer. When an intersection with existing communications equipment is modified or upgraded, the existing communication equipment shall be reinstalled in the newly completed signalized intersection and fully functional unless new communication equipment is specified in the project plans and documents.

2.1.4.1 Extension of Existing System

If a new signal is to be added to an existing hardwire connection, a local controller with adequate cabinet space for an interconnect panel must be designated as the system supervisor. If the signal modifications are significant, the replacement of the hardwire systems with a more advanced interconnect system may be necessary.

To connect a new signal with an existing twisted pair connection, a local controller must be designated as the system supervisor and communications boards must be installed in each controller.

If a new signal is to be added to an existing closed-loop system or if an existing communication system is being upgraded to a closed-loop system, all controllers must be of the same make or all controllers must be upgraded.

2.1.4.2 New System Implementation

New signal installations shall require the inclusion of network communication infrastructure to allow management of the signal controller from the City's existing Traffic Management System. In locations where the City maintains existing fiber optic infrastructure, fiber Ethernet network equipment shall be provided. Ethernet Field Switch shall be RuggedComm Model No RS900G. In all other locations, the Data Pass-through services from Glance (see section 2.1.4 above) shall be utilized to provide communication to all networkable devices.

2.1.5 Signal Wiring, Conduit and Junction Boxes

All signal head wiring is required to be seven (7) conductor stranded, regardless of signal head (3-, 4- or 5- section heads). Wiring from cabinet to signal heads should have no joints. Terminations are to be made in signal heads and cabinets only. Any changes to an existing intersection with solid wiring will require complete re-wire of all components using stranded cable. At existing span wire intersections, removal of existing lashing may be required when new wire is added. Adding new wire over existing lashed wire shall not be permitted unless old lashing is removed. Lashing shall be aluminum lashing tape only. For Flashing Yellow Arrow (FYA) signal installations, signal head wiring is required to be ten (10) conductor stranded. Four (4) conductor shall be used to connect the from the FYA head to the concurrent phase 3-section signal heads. The following wiring standard should be used until IMSA or ALDOT standards are developed.

Conductor #	Wire color	Signal indication
1	Black	Yellow ball
2	White	Neutral
3	Red	Red ball
4	Green	Green ball
5	Orange	Yellow arrow
6	Blue	Green arrow
7	White with black stripe	SPARE
8	Red with black stripe	FYA red arrow
9	Green with black stripe	SPARE
10	Orange with black stripe	FYA yellow arrow

A minimum of two (2) – 2" conduit are required for signal cable from the controller cabinet under roadways. Two (2) – 2" conduit is also required for signal cable and loop returns, once the run has crossed the roadway. All above ground conduit is required to be rigid metallic, while PVC Schedule 40 conduit is the standard for trenched underground conduit and continuous run HDPE conduit is the standard for underground bored conduit. A spare 2" conduit shall be stubbed out of each pole foundation and the cabinet pedestal for future use.

Traffic rated junction boxes of a minimum size of 17"x 30" and minimum Tier 15 rating are required for all installations throughout the City, regardless of location within the right-of-way. Junction box lids shall have "traffic" molded into the lid. Any joints within underground junction boxes shall be water-tight connectors and approved by the Traffic Engineer.

2.1.6 Power Supply

The electrical power source for the controller cabinet shall be underground. It shall be designated on signal plans in the same quadrant as the signal controller. The power source should be verified by the engineer in the field with a representative of the power company before the power source is located on the plans. The service disconnect shall be black and constructed in accordance with the standard detail shown in Appendix H. All conduit, wire, bonding, and other required miscellaneous components shall be internally routed in pole. Any charges imposed by the utility company for service shall be paid by the project contractor or signal contractor.

An uninterruptible power system (UPS) (battery back-up system Clary SP 1250LX or approved equal) is required for all intersections. The entire UPS system and batteries shall be housed in the traffic signal controller cabinet with integrated UPS cabinet. When added to an existing cabinet without space for the UPS, the UPS and batteries shall be housed in a 336S cabinet. The UPS shall use the OP72C battery. Aesthetics should be considered when designing the location and style of the power service supply and disconnect to maintain the standard established by the decorative black poles.

2.1.7 Vehicle Detection

The type of vehicle detector used depends upon the type of information needed by the controller to operate efficiently at its location with respect to the roadway. There are two (2) types of inductive loop detectors, as well as video detection, which are acceptable for use within the City. The type of detection used at each intersection shall be approved by the City Engineer. Video detection shall be required at all new or improved intersections. Other types of detection may be considered and approved at the discretion of the City Engineer. All detection, regardless of type, shall be capable of obtaining and providing volume data via the mesh network and shall detect and respond to the presence of bicycles.

The inductive loop detects vehicles by sensing a change of inductance in the loop caused by the passage or presence of a vehicle over the loop. This type of detection is made up of three (3) components: a loop of wire sawcut into the roadway surface, a lead-in (home run) cable and an amplifier unit in the controller cabinet. It is capable of both passage and presence detection. All loops sawcut into the road way shall have individual homerun cables and individual curb side cut outs. Loops shall be installed and tested in accordance with ALDOT

Standard Specification 730(p). Testing results for each loop shall be provided to the Traffic Engineer for approval.

Video detection utilizes video cameras and an image processor to detect the presence of a vehicle to determine when to activate a particular phase.

2.1.7.1 Stop Line Detection

Stop line detection, as the name implies, are inductive loops located at or near the stop line on an intersection approach to detect the presence of stopped vehicles and operate in the presence (non-locking memory) mode of detection. Stop line detection is typically used on low speed [twenty-five (25) mph or less] and side street approaches. They are typically used in through lanes on minor approaches (at a minimum), in left turn lanes on both major and minor approaches and across bicycle lanes. When used with a delay, stop line detectors can screen out right turns made on red, or left turns clipping opposing lanes, thus preventing false calls.

The standard size loop is six (6) feet by forty (40) feet regardless of lane widths. At large radius intersections, wider loops may be used. The width of the loop in a curbside lane can increase significantly when it is located ten (10) feet back from a cross street and the intersection has large curb radii.

2.1.7.2 Advanced Detection

Advanced detection are inductive loops that can be used with volume density controllers and are located some distance in advance of the approach stop line. The advanced loop is six (6) feet by six (6) feet and located in the through lanes of the major street where speeds are thirty (30) mph or greater. These loops operate in a passage or pulse mode and detect vehicles as they pass a specific point. Advanced loop detection can provide the controller with information on vehicles approaching the intersection, and in the case of a volume density controller, can count the number of vehicles on the approach that are waiting with a red signal indication. The location of these loops is based on the safe stopping distance of approaching vehicles which varies according to the approach speed.

TABLE 2.1
Advanced Detector Location

Approach Speed	Loop Setback
30 mph	140'
35 mph	185'
40 mph	230'
45 mph	285'
50 mph	340'
55 mph	405'

Source: ITE *Manual of Traffic Signal Design*, 2nd Edition

2.1.7.3 Video Detection

Video detection can operate in both presence and passage mode, similar to stop line and advanced detection. Detection zones are designated in the image processor to detect the presence of a vehicle and a bicycle and send a call to the controller. Video detection is often used in place of stop line detection, but can also be used for advanced detection (may

require cameras downstream of the intersection). If the intersection cameras cannot detect advancing vehicles because of the topography and additional downstream cameras are not feasible, advanced loops may be necessary.

The latest model color Ieteris camera and VRack (mounting rack) or approved equal are required at all intersections operating with a video detection system. Video detection shall be routed back to the Traffic Management System utilizing Edge Connect Modules. Cameras are to be mounted on a mast arm on the far side of the intersection. Proper mounting height is necessary, and varies by location, to ensure the cameras have an acceptable field of vision. ALDOT recommends mounting heights from thirty (30) to forty-two (42) feet. Engineering judgment is required to determine the ultimate mounting location. All cameras and mounting hardware for video detection shall be black. Powder coated black cable mount brackets shall be used for mounting.

2.1.7.4 Wireless Detection

Wireless detection shall be compatible with and interchangeable with the existing wireless systems provided by Sensys Networks.

2.1.8 Railroad Pre-Emption

The MUTCD states that railroad pre-emption shall be provided whenever the distance between a rail crossing and traffic signal is two hundred (200) feet or less. Additional warrants include:

- Analysis that indicates vehicle queues from a traffic signal have the potential to extend into or past the rail crossing, and
- Analysis that indicates vehicle queues caused by a passing train have the potential to extend into the signalized intersection and obstruct traffic flow.

The maximum [ninety-five (95%) percent] queue is recommended to be used when determining whether the queue will extend into the track area [within eight (8) feet of the nearest rail]. Refer to ALDOT's *Traffic Signal Design Guide & Timing Manual* for the standard pre-emption sequence and guidelines for computing the minimum interval times.

2.1.9 Intersection Signage

This section presents only the most commonly required signing associated with traffic signals. Guidance for additional signing may be found in the MUTCD, latest edition.

Spanwire/Mast arm mounted sign arrangements shall be installed in conformance with the MUTCD, latest edition. Where overhead signs are installed, they shall have a minimum of seventeen (17) foot vertical clearance over the roadway. Examples of these signs include:

1. Left Turn Signal Signs R10-10, R10-12,
2. Lane Control Signs R3-5 through R3-6a,
3. Turn Prohibition Signs R3-1, R3-2, R3-4, R10-5, R10-11a,
4. Street Name Signs D3-1.

Ground mounted signs to be used at or in advance of signalized intersections shall be installed in conformance with the MUTCD, latest edition. Examples of these signs include:

1. Turn Lane Supplemental Sign R3-7,
2. Signal Ahead Sign W3-3,
3. Street Name Signs D3-2.

Street name signs shall be LED internally edge lit illuminated signs with high intensity prismatic white letter on the standard City of Auburn blue background. They shall be equipped with flip front faces for field maintenance. Frames shall be gloss black in color. All mounting hardware for illuminated signs shall be black under-hang brackets for use with two-sided signs. Each individual sign shall be fused at the base of the pole unless otherwise approved by the Traffic Engineer. Power for the illuminated signs shall be served from the luminaire circuit at the base of the corresponding pole. One black photoelectric cell shall be located on the bottom of the disconnect to control both signs.

Traffic control signs used at signalized intersections in the City shall be high intensity prismatic and of the size specified in the MUTCD. The unit measurement for these signs as shown in signal plans shall be in square feet of sign face.

2.1.10 Pedestrian Signal

Pedestrian signals shall be LED countdown signal heads (Lumination PS7-CFF1-01A-18), with a “walking person” indication and a “flashing/steady upraised hand”. Audible devices shall also be installed to provide standard information about the status of the signal cycle to pedestrians with disabilities. Pedestrian signal housing shall have a gloss black finish. All mounting hardware for pedestrian signal heads shall be black clam-shell brackets drilled and tapped to the pole.

Pedestrian push buttons shall be provided on their own individual poles on the appropriate approach with an audible push button for each crossing direction. Pedestrian push button poles shall be installed in accordance with the standard detail shown in Appendix H. Pedestrian push buttons shall be POLERA Navigator (or approved equal) compliant with Public Rights-of-Way Accessibility Guidelines’ (PROWAG) issued by the United States Access Board. Each push button is to be supplemented by sign R10-3i, which includes the street name of the street to be crossed with an arrow pointing in the direction of the crossing. The street name shall also be identified in Braille. Audible push button programming shall be implemented in accordance with the latest edition of the MUTCD including all individual street names and messages. Standard Polera settings for volume and tones may be obtained from the Traffic Engineering Department.

All pedestrian signal head wiring shall be five (5) conductor stranded. Two (2) conductor stranded 50-2 wire is required for pedestrian push buttons. The following wiring standard shall be used:

Wire Color	Termination
Red	Pedestrian Head "Don't Walk"
Green	Pedestrian Head "Walk"
White	Pedestrian Head Neutral
Black	Pedestrian Push Button Positive (+)
Orange	Pedestrian Push Button Negative (-)

The pedestrian signal phase is a special sequence actuated by pedestrian push buttons to allow pedestrians to safely cross a street.

2.1.10.1 Warrants

A pedestrian signal phase with pedestrian signal heads shall be installed when any of the following occur:

1. When Signal Warrant 4, "Pedestrian Volume" is fulfilled,
2. When Signal Warrant 5, "School Crossing" is fulfilled,
3. Where there is an established school crossing at the proposed signal location,
4. Where pedestrians are present and multiphase signal operations (lead-lag left turns, split phasing, etc.) are used that could confuse the pedestrians,
5. Where a sidewalk approaches the intersection on opposite sides of the intersection and on the same side of the street.
6. As required by the City Engineer.

2.1.10.2 Sequence

The most commonly used sequence is to move pedestrians concurrent with parallel vehicular traffic. Care must be taken however not to move pedestrians during the display of a conflicting left turn or right turn arrow for the parallel vehicular traffic. The exclusive movement sequence moves pedestrians on a phase totally separate from any vehicular phase. When used, pedestrians cross all approaches simultaneously. This sequence should only be used where both pedestrian volumes and conflicting vehicular turning movement volumes are high.

2.1.10.3 Timing

Walk timing provides the time necessary for a pedestrian to leave the curb to cross the street. Its minimum setting ranges from three (3) to seven (7) seconds. Pedestrian clearance time shall be calculated utilizing the latest edition of the MUTCD. It is calculated using the equation:

$$PC = W / V_P$$

Where: PC = Pedestrian Clearance (sec)
W = Width of street (ft)
V_P = Pedestrian walking speed (see MUTCD latest edition)

A portion of the pedestrian clearance interval can be timed simultaneously with the yellow and all red intervals of the concurrent vehicular phase.

2.1.11 Intersection Lighting

A twelve (12) foot luminaire arm with a Phillips Roadstar 130 130W98LED4K (or approved equal) cobra head fixture shall be installed on all traffic signal poles at the intersections. Luminaire assembly shall be painted with a gloss black finish and include an equivalent to a two hundred fifty (250) watt high pressure sodium fixture. Each fixture shall be individually fused at the base of the pole. All luminaires shall be controlled by individual photocells located at each luminaire housing.

2.2 SIGNAL TIMING

Traffic signal timings shall be developed in accordance with the criteria established by the MUTCD, Federal Highway Administration (FHWA) *Traffic Signal Timing Manual* and the ALDOT *Traffic Signal Design Guide & Timing Manual*, latest editions. The engineer should consult with the City Traffic Engineer to determine whether a traffic signal will operate as actuated. Fixed time signals are often used in the downtown area and on low volume roads. Actuated signals with a fixed cycle length are more commonly used.

2.2.1 Cycle Lengths

Signal cycle length is the total time required to complete one (1) sequence of signal phases and generally should be as short as possible. Table 2.2 “Typical Cycle Length Ranges” contains guidelines regarding typical cycle length ranges. Cycle lengths should be calculated for the A.M. peak hour, the P.M. peak hour and off peak periods, as a minimum. If the cycle lengths vary by more than ten (10) seconds, each period should operate on a different cycle length. Signal timing software should be utilized to determine optimum cycle lengths.

TABLE 2.2
Typical Cycle Length Ranges

Traffic Volumes	Typical Cycle Length Range
Low	50 – 90 sec.
Moderate/High	90 – 130 sec.
Congested	130 – 180 sec.

Source: ALDOT *Traffic Signal Design Guide and Timing Manual*, November 2007

2.2.2 Actuated Timing Parameters

The following timing parameters are for stop line detection of an actuated signal: minimum green, vehicle extension (passage time), maximum green (I and II), yellow all red, walk and pedestrian clearance. The following timing parameters are for advanced detection of a volume density signal controller. These features are typically used for approach speeds thirty (30) mph or greater and provide a variable (minimum) green as well as a variable “gap” feature. The timing parameters are: minimum initial (minimum green), added initial, initial gap (passage time), time before reduction, time to reduce, minimum gap, maximum green (I and II), yellow, all red, walk and pedestrian clearance.

2.2.3 Signal Timing Plans

A signal timing plan is the combination of cycle length, phasing, splits (green + clearance for each phase) and offsets (for coordinated systems) and should be included with traffic signal plans. When the signal is part of a coordinated system, the signal shall be incorporated into the existing coordinated system timing plans. New coordinated system timings shall be required for all signals within the system when necessary to incorporate new signals or geometric improvements.

2.3 PLANS PRODUCTION

A Traffic Signal Plans Submittal Checklist has been provided in Appendix F to facilitate a more efficient plan review process for the designer and the review team. The checklist must be submitted with every set of plans for traffic signal improvements or new signal installations. The various signal plan sheets, their format and contents are described in this section. At a minimum, all plan sheets shall have a title block containing the intersection or corridor name, a scale, the design date and the design firm information, including the initials of the designer. The title sheet shall be stamped, signed, and dated by the engineer of record that supervised the design and plans production.

2.3.1 Traffic Signal Notes

This sheet contains, as the name implies, notes of general nature that apply to all the signalized intersections in the plans. It generally includes items from the ALDOT Standard Specifications for Highway Construction (latest edition) for which emphasis is intended for the contractor. The most frequently used notes are shown in Appendix G.

2.3.2 Signal Plan

Signal plan sheets shall illustrate the basic intersection geometry, channelization, driveways, ditches, right-of-way, the location of underground and aerial utilities, utility poles, pavement markings, construction stationing (if available), and the power source for the controller cabinet.

The following information concerning the timing, phasing and installation of the signal is also required on the signal plan sheet.

2.3.2.1 Installation Notes

This set of notes applies to the signal installation at a particular intersection only. It should not repeat notes covered in the signal general notes section. Items typically covered in these notes include but are not limited to:

- Signal Controller/Cabinet – Specifies installation and type
- Electrical Service – Specifies installation
- Junction Boxes – Specifies installation and type
- Signal detectors – Specifies installation
- References – Refers to the signal General Notes and the signal timing and operations sheets for additional information
- Speed Limits – Posted speed limits on all intersection approaches
- Flashing Operations – Yellow to major street, red to minor street.

2.3.2.2 Signal Head Displays

This diagram shows the signal indication arrangement for each head on the signal plan. It also specifies the signal indication lens size twelve (12) inches and signal head housing color (yellow).

2.3.2.3 Signage Displays

This diagram shows the sign type, MUTCD designation and size for each sign called for on the signal plans. If a non-standard sign, such as a street name sign, is called for, its size, color and legend must be specified.

2.3.2.4 Pre-Emption Phasing Diagram

If emergency or railroad pre-emption is included in the signal design, a pre-emption phasing diagram is needed to show all the phasing sequences possible when the signal is pre-empted. The phase in which normal operations is to resume after pre-emption is to be designated. Normally pre-emption is limited to major roadways and not side streets. Exceptions would be if there was a fire/EMS station or hospital located on the side street.

2.3.2.5 Signal Sequence Chart

This table contains all the timing parameters applicable for the type of signal specified in the plans. The timing is shown for each signal phase in addition to its recall status.

2.3.2.6 Conflict Monitor Chart

The conflict monitor chart contains the permissible or safe phase combinations to be hardwired into the conflict monitor. Any combination not wired into the circuit board will trip the conflict monitor and place the signal into flash mode.

2.3.2.7 Wiring Diagram and Table

The wiring diagram shows the wiring required to accommodate the signal heads, detectors, signal controllers and power source for the signal installation shown on the signal plan. For clarity purposes, the combination of conductors required in each different section of the wiring diagram may be designated with a letter code corresponding to a wiring combination shown in the wiring table.

The wiring table is a chart that describes the various conductor combinations as designated by the letter code on the wiring diagram. The wiring code should include all runs both aerial and underground. It also specifies the conduit size needed for each particular combination of conductors run underground.

2.3.2.8 Materials List

This chart shall list the components of the signal equipment that are covered under the 730 "Furnishing and Installing Traffic Control Unit" pay item. Computed quantities are not necessary as they are part of a lump sum pay item. The following items, as applicable, should be listed in a box on the plan sheet:

- 3/8" messenger cable
- 1/4" tether wire
- #14 signal cable
- Power source (specify 120V or 240V)
- Miscellaneous hardware
- Span mounted signs with hardware (ex. R10-12, R10-10, etc.)
- Backplates with hardware
- Weatherheads
- Pedestrian signal displays

- Pedestrian pushbutton assemblies.

2.3.3 Details and Standard Drawings

The traffic signal plans shall also include all standard details, drawings and specifications as applicable to the signal design. This includes, but it not limited to the City's Standard Decorative Pole Assembly and the applicable ALDOT Traffic Signal Operating Plan. Typical details, drawings and specifications are provided in Appendix H of this Manual.

2.3.4 Communication Plan

A communication or interconnect plan shall be required if a traffic signal is being coordinated with other signal installations, via hardwire, radio, fiber optic or other. The plan shall illustrate required equipment such as master controllers, and the placement of communication cable, either underground or aerial, and tabulate all related interconnect quantities. The communication plan sheet shall indicate all signal and/or utility poles to which communication cable will be attached. In the case of radio coordination, the plan shall illustrate all necessary antennae, master controllers or other required equipment.

2.4 CONSTRUCTION

A certified Traffic Signal Technician shall have active involvement with all work required for the installation and operational testing of electrical materials and equipment (conduit, boxes, conductors, etc.). A pre-construction meeting is required prior to any work on existing or new traffic signals. The developer, general contractor, and/or electrical contractor(s) performing the work are required to be in attendance. This meeting may be held in conjunction with the project preconstruction meeting or as a stand-alone meeting.

All installations shall comply with the regulations of the National Electrical Code and the National Electrical Safety Code, latest editions, and with the service rules of the electric service provider. Prior to beginning work, contractors shall provide at least 48 hours notification to the Traffic Engineering Department.

In the case of a signal upgrade, existing equipment that is not in operation at the project site shall be returned to the Engineering Services Department.

2.4.1 Materials Submittal

Equipment shop drawings and manuals must be submitted to the City for approval before materials are ordered. All materials furnished for use shall conform to the requirements given in the ALDOT Standard Specifications for Highway Construction, latest edition. Materials shall also comply with requirements that may be given on the plans. Concrete for foundations shall comply with the requirements for Class A, Type 2a concrete. Reinforcing steel shall meet the requirements for steel reinforcement and shall be Grade 60 (400) billet steel. Minimum design wind speed shall be based on ALDOT standards. All materials and equipment furnished shall be new, except when the plans specifically provide for the re-use of existing equipment.

2.4.2 Test Requirements

Before the installation of a traffic control systems, the contractor shall perform a pre-installation test. This test shall include the bench testing of all controllers, signals, detectors, etc., under signal load conditions for fourteen (14) consecutive days. The contractor shall secure an acceptable site, approved by the engineer, for the bench test and shall perform all work required in the performance of the test. The contractor shall notify the engineer of the date that the test is to begin a minimum of seven (7) days before that date. None of the equipment shall be installed on the project until the bench test has been completed and the contractor has submitted a letter to the engineer certifying that the equipment performed satisfactorily during the test. The engineer may shorten the length of time required for the bench testing. There will be no direct payment to the contractor for the cost of the pre-installation test including the cost of a suitable test site and the setting up of equipment for the test.

2.4.3 Inspection

Some materials and equipment required to be furnished will be standard production type products. Acceptance will be made by the engineer based on selected confirmation tests, the manufacturer's certification of the materials and equipment, and visual inspection at the job

site. The manufacturer shall make available to the City Engineer test data and material samples from the production runs for use in evaluation of these items. Approved devices are shown on ALDOT's Approved Traffic Control Devices and Materials list.

Concrete pole foundations shall be inspected by the Traffic Engineering Division before and after concrete is poured. Upon completion of the project, the contractor shall schedule a full operations traffic signal inspection with the Traffic Engineering Department. Results of the inspection shall be provided to the contractor in the form of a punch list. All items on the punch list must be satisfactorily addressed prior to releasing payment. Contractor shall give at least one day's notification for inspections.

2.4.4 Closeout

After all equipment has been installed and the operational check has been instigated, the contractor shall submit a set of plans showing in detail all changes on construction from the original plan details with special notation given to conduit location and elevation and schematic circuit diagrams. Operation manuals and as-built wiring diagrams shall be furnished for all equipment and accessories required in the controller cabinet. These manuals and wiring diagrams shall be mounted to the cabinet in an appropriate manner.