

CHAPTER 9

TRAFFIC CONTROL DEVICES

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CHAPTER 9

TRAFFIC CONTROL DEVICES

9-01 GENERAL

Traffic control devices include signs, signals, markings and other devices placed on or adjacent to a highway or street to regulate, warn or guide traffic. The legal authority to install traffic control devices on Commonwealth highways is vested in the Secretary of Transportation and Public Works.

The Federal Highway Administrator adopted the 1971 "Manual of Uniform Traffic Control Devices", referred to as the MUTCD, developed with the cooperation of the AASHTO and the National Joint Committee on Uniform Traffic Control Devices, as a national standard for application on all classes of highways. The Secretary of Transportation and Public Works has officially adopted the MUTCD as a guide for the design and application of traffic control devices in Puerto Rico subject to the requirements of the Vehicle and Traffic Act (Law No. 141 of 1960 as subsequently amended) and to such modifications as required to meet local conditions, including the translation to Spanish of all word messages on signs and markings. The Department is now in the process of developing its own manual of uniform traffic control devices in Spanish, based on the MUTCD, to provide an official guide for application throughout the Commonwealth.

In addition to the MUTCD, the designer has available the Department's 1964 "Manual of Traffic Signs" which provides fabrication and installation details for standard traffic signs. This manual is supplemented by standard plans covering signs not included in the original edition or since revised and new details on sign posts and supports. A revision and updating of this manual is now in process.

This chapter is intended for the use of the highway designer as a supplement to the above manuals.

9-02 TRAFFIC SIGNS

9-02.01 SPECIAL SIGNING STANDARDS

The Department's Bureau of Traffic Engineering has issued a set of instructions, to be used as a supplement to the MUTCD, which cover special standards for signing of expressways and other highways in Puerto Rico. These special standards are in general conformance with the MUTCD but provide specific instructions on sign sizes, location, messages, letter series and sizes, and other details for use on various types of highways and conditions.

9-02.02 COORDINATION WITH HIGHWAY DESIGN

Effective signing is essential for the proper operation and safety of highspeed arterial highways, particularly expressways and freeways. The signs must be designed and located so that the drivers can react promptly, naturally and safely to the design conditions. However, good signing cannot correct a poor highway design. During the early stages of the design of an expressway, a preliminary signing plan should be prepared and analyzed to ascertain that the facility can be clearly signed. When this is not possible, modifications of the geometric layout may be warranted. Urban expressways with restricted geometrics, complex layouts and closely spaced interchanges require careful consideration of signing during the early design stages since they often pose special problems in sign location and spacing.

9-02.03 SIGN LOCATION AND SUPPORTS

The locations of the various types of signs are specified in the MUTCD, the Department's Manual of Traffic Signs and the special instructions issued by the Department. The design of sign supports, other than for overhead sign structures, are covered in the standard model plans.

All ground-mounted signs on rural highways and on all expressways and freeways shall be of the breakaway design or yielding type posts in the case of small signs. They should be placed behind guardrail whenever possible. However, guardrail should not be installed merely for the protection from sign supports except in the case of large overhead sign installations for which breakaway supports cannot be provided. Also, care must be exercised that sufficient offset of the sign support from the face of the guardrail is provided to allow for the expected deflection of the rail.

The lateral offsets from edge of traveled way for sign panels placement on rural highways indicated in the signing manuals are to be considered as minimums. On high-type rural highways with wide sections, large traffic signs should be offset from the traveled way further distances than the minimum for increased safety and still communicate effectively. However, care must be taken to obtain a satisfactory angle for the sign face in relation to the approaching traffic and to provide favorable viewing conditions. A minimum of six (6) feet shall be provided from the left edge of sign panels and the curb or edge of shoulders to avoid traffic damage on urban areas.

Full advantage should be taken of overcrossing structures on expressways for sign placement whenever possible. Such installations are more effective and safer than ground mounting, and more economical than a separate sign bridge.

Breakaway sign supports generally should not be used on sidewalks on streets and avenues since falling posts and signs can be hazardous to pedestrians. The need of breakaway supports to protect vehicle occupants is not as essential on streets since accidents are generally less severe due to the lower operating speeds.

9-02.04 GORE AREAS

Gore areas are probably the portions of a highway most vulnerable to frequent encroachment by errant vehicles. For this reason they should be kept clear of sign installations except for the ground-mounted gore EXIT sign which should always be on breakaway supports. The supports for other signs required in the vicinity of the gore should be located ahead of the clear gore area and outside the right shoulder. Some overhead sign structures may require a support to be located in the median.

9-02.05 OVERHEAD SIGNS

1. WARRANTS—Overhead sign installations are expensive because of the cost of the support structure. However, overhead signs are very effective, particularly for directional signs and lane use control on high-speed multilane highways. The use of overhead signs on expressways should be considered on the basis of the following factors:

- a. Complex interchange design.
- b. Three or more lanes in each direction.
- c. Closely spaced intersections and interchanges.
- d. Multilane exits.
- e. Insufficient space for ground signs.
- f. Restricted sight distance.
- g. Traffic volume at or near capacity.
- h. Large percentage of trucks.
- i. Consistency of sign message location throughout a series of intersections or interchanges.

2. **VERTICAL CLEARANCE**—Signs located over any portion of the roadway shall have a vertical clearance of at least 0.30 m. more than the minimum vertical clearance provided for other structures along the same highway sections, but in no case less than 5.0 meters. When the overhead sign is attached to an overpassing structure, the vertical clearance to the sign need not exceed the vertical clearance to the structure.

3. **HORIZONTAL CLEARANCE**—The minimum horizontal clearance from edge of traveled way to a non-breakaway overhead sign support shall be 4.2 meters with guardrail protection provided. The guardrail installation shall be designed in accordance with the requirements included in Chapter 8. However, whenever feasible this minimum clearance should be exceeded for greater safety. A horizontal clearance of 9.0 M. is very desirable on high-speed highways. An impact attenuator or guardrail immediately adjacent to the overhead support shall be provided no matter how much the clearance is.

4. **STRUCTURAL DESIGN**—The structural design of the structural supports for overhead signs shall conform to the requirements of the AASHTO "Specifications for the Design and Construction of Structural Supports for Highway Signs". The wind pressure shall be determined using a wind speed of 120 mph (50 year mean recurrence interval) in the formula.

5. **ILLUMINATION**—All overhead signs shall be reflectorized in accordance with the Department's requirements. In addition, all overhead signs shall be illuminated on expressways and other high-speed highways except at locations where it can be positively shown that reflectorization alone will provide adequate visibility and contrast at night. Sign illumination, when provided, shall conform to the requirements covered in Standard Specification 613. Sign luminaires shall be bottom mounted to avoid daytime shadows on the sign. They shall be designed to produce a brightness of no less than 25 footlamberts on the white legend with a maximum to minimum ratio of brightness of not more than 3:1.

9-02.06 **KILOMETER AND HECTOMETER MARKERS**

Kilometer and hectometer markers shall be installed on all numbered Commonwealth highways. These markers indicate the distances along the highway from its point of origin as defined by the official route description approved by the Department. The designation and location (station) of the initial marker for a particular project is to be established by the Design Area in coordination with the Planning Area. The kilometer and hectometer markers are to be fabricated and installed in accordance with Standard Model No. 3 and Standard Specification 621.

9-02.07 **PLAN REQUIREMENTS**

The signing plans for a project shall include the following:

1. **SIGN LOCATION PLAN**—This is a plan showing the location of each sign or sign assembly. Signs are identified by a symbol giving the location number and the type code number. A sample portion of a location plan is illustrated in Figure 9-A. The approximate station location of each sign should be indicated. The standard project plan sheets (Scale 1:1000 or 1:500) may be used for the sign location plan. For intersections or interchanges with a lot of signing, the larger scale detail plan sheets may be used. The designer should provide plans showing all necessary traffic control devices for the anticipated detours, or special conditions that are expected during the construction phase.

2. **TRAFFIC SIGNS DATA SHEET**—This is a tabulation of all the signs required for the project. A portion of a sign data sheet is illustrated in Figure 9-B. The following is an explanation of the column headings:

Code Number — The code for each particular type of sign indicated in the upper portion of the symbol used in the location plan.

Location Number -- The number(s) of the location(s) where each type sign is to be installed as indicated in the lower portion of the symbol used in the location plan.

Legend -- A graphic illustration of the legend for the particular sign used.

Letter Size -- For standard signs reference is made to the DTPW "Traffic Signs Manual" or a standard model plan as appropriate. In the case of guide signs or other signs for which a specific design must be made, the size and series of letters to be used is given and reference is made to the appropriate guide sign detail sheet.

Size of Sign -- The overall dimensions of each sign are indicated. In the case of assemblies of two or more signs, the dimensions of each sign are shown.

DTPW Number -- This refers to the identifying number for each particular type of sign used in the DTPW signs manual or standard models.

Colors -- The colors of the background and characters are shown and reflectorization, if any, indicated.

Type of Mounting -- For ground mounted signs reference is made to the particular standard model applicable (3-E-1, 3-E-2, etc.). For overhead signs reference is made to the plan sheet where design data for the support structure is shown.

Total Signs -- Indicates the total number of signs (or sign assemblies) of each particular type needed. This number should correspond to the total number of locations shown in the second column.

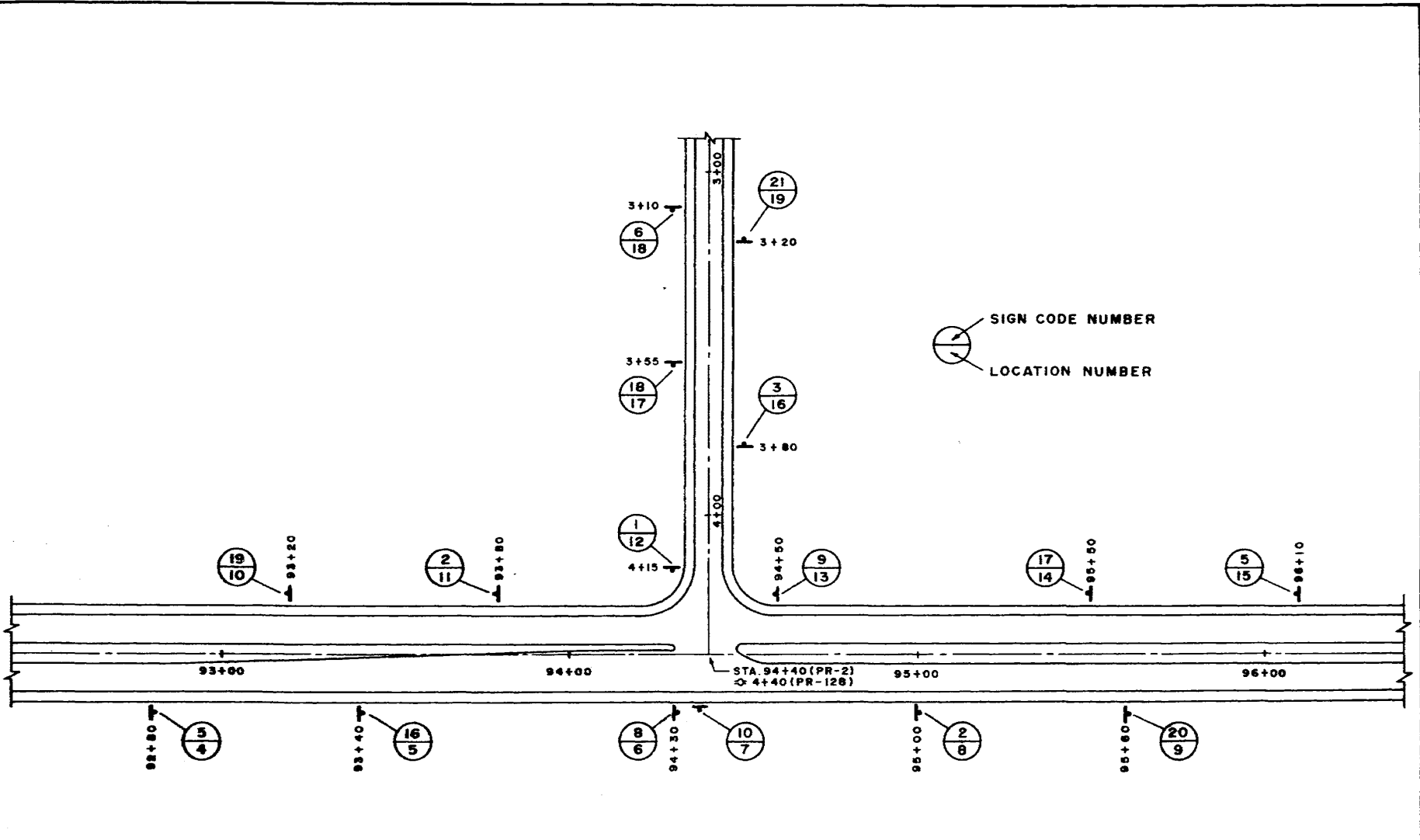
3. GUIDE SIGNS DETAILS--For each guide sign a layout will be included showing the overall sign dimensions, the letter sizes and series, and the dimensions and spacing for the legend. A sample of a typical guide sign layout is illustrated in Figure 9-C.

4. OVERHEAD SIGN STRUCTURES--A general layout and elevations shall be included for each overhead sign structure showing the type and dimensions, location with respect to roadway section, clearances, foundations, and positioning of signs. In addition, all necessary design criteria will be indicated, including illumination requirements, to enable the contractor to develop the detailed design of the structure and subsequent shop drawings. For illuminated signs, the location of underground conduits and lines to power source shall be indicated on a plan layout.

5. SPECIAL DETAILS--Design details of any special type of sign supports not covered by the standard models shall be shown. This includes such items as special brackets for supporting signs from overpassing structures or from roadside walls.



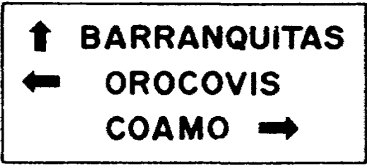
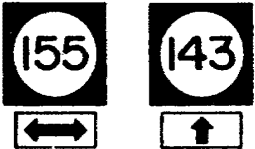

9-03 MARKINGS

Markings include all pavement and curb markings and other devices, other than signs, which are used to guide traffic or warn of an obstruction such as delineators and object markers. The Department adheres to Part III of the MUTCD in the design and application of traffic markings.



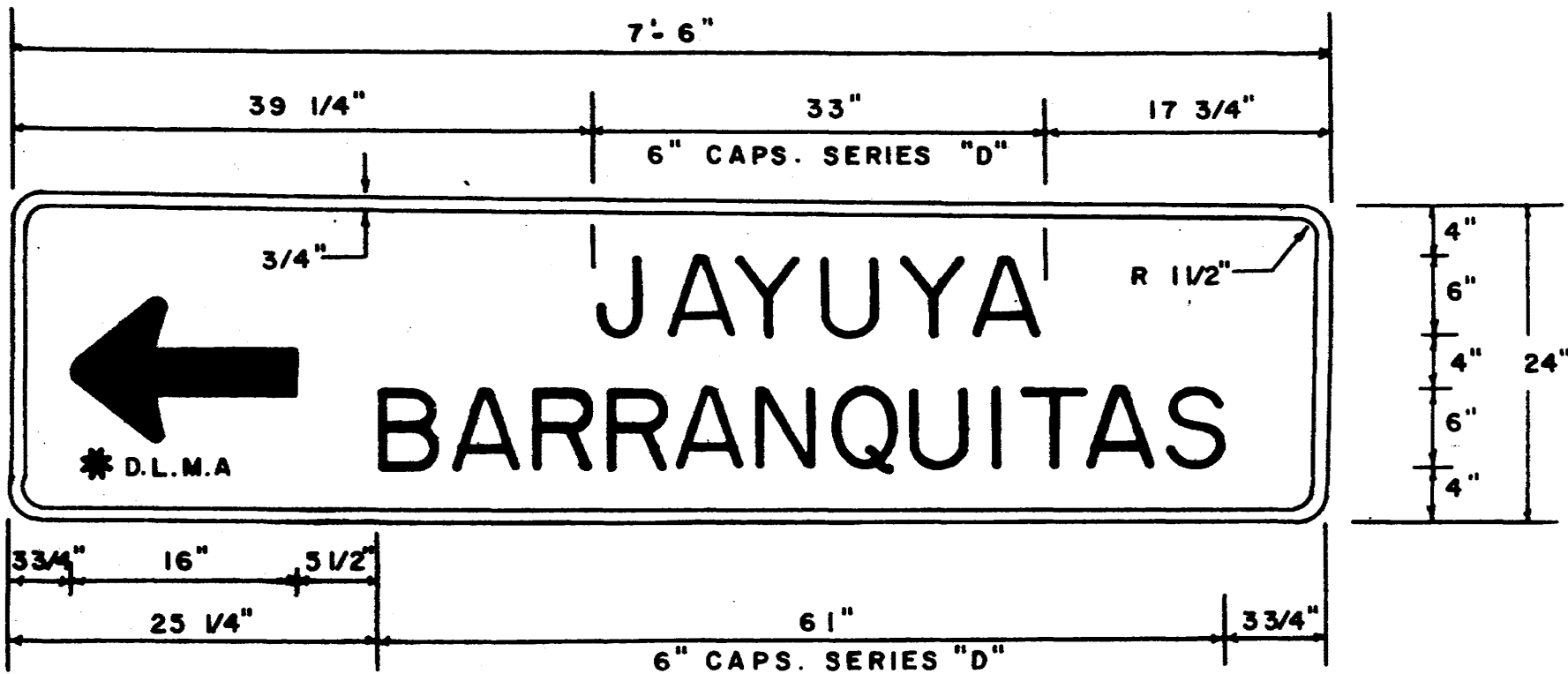
PORTION OF A SIGNS LOCATION PLAN

FIGURE 9-A

CODE NUMBER	LOCATION NUMBER	L E G E N D	LETTER SIZE	SIZE OF SIGN	DTPW NUMBER	C O L O R S		TYPE OF MOUNTING	TOTAL SIGNS
						BACKGROUND	CHARACTERS		
1	1, 2, 15, 16		SEE DTPW MANUAL	30"x 30"	R1-1	RED REFLECTORIZED	WHITE REFLECTORIZED	STD. MODEL 3-E	4
2	3, 6		SEE DTPW MANUAL	21"x 15" 24"x 24"	M2-1 M1-1	WHITE REFLECTORIZED	BLACK	STD. MODEL 3-E	2
3	4		6" CAPS. SERIES D SEE PLAN SHEET NO. 52	7'-6"x 2'-8"	D1-3	GREEN REFLECTORIZED	WHITE REFLECTORIZED	STD. MODELS 3-E-3,4,5	1
4	5, 7		SEE DTPW MANUAL	24"x 24" 21"x 15" 24"x 24" 21"x 15"	M1-1 M4-4 M1-1 M4-3	WHITE REFLECTORIZED	BLACK	STD. MODEL 3-E-1	2
5	8, 9, 17, 18		SEE DTPW MANUAL	24"x 30"	R2-1	WHITE REFLECTORIZED	BLACK	STD. MODEL 3-E	4

PORTION OF TRAFFIC SIGNS DATA SHEET

FIGURE 9-B



TYPICAL GUIDE SIGN LAYOUT

FIGURE 9.C

* D.L.M.A. - DOUBLE LINE MESSAGE ARROW

9-03.01 PAVEMENT MARKING MATERIALS

The Department uses three types of pavement marking materials; paint, thermoplastic compound, and raised markers.

Paint with embedded glass beads to provide reflectorization is the most commonly specified material for pavement markings. Paint and bead requirements are covered in Standard Specification 618.

The use of extruded thermoplastic compounds is normally limited to expressways and other heavily traveled multilane rural and urban highways. Thermoplastic markings are also reflectorized by the use of embedded glass beads.

Raised pavement markers are currently being used on some freeways for lane line marking in lieu of paint or thermoplastic. Two types of markers are used in combination. These are a non-reflectorized ceramic marker (Special Provision 802) and a retro-reflective plastic marker (Special Provision 801).

9-03.02 PAVEMENT LINES – WIDTHS AND PATTERNS

Center lines, lane lines, pavements edge lines and no-passing zone lines shall be 4" (10 cm) wide. Broken lines shall have 15' (4.6 m) segments and 25' (7.6 m) gaps. Space between double lines shall be 4" (10 cm).

Stop lines shall be 24" (60 cm) wide on high-speed highways and 12" (30 cm) on all other roads and streets.

Crosswalk boundary lines shall be 12" (30 cm) wide where no advance stop line is provided and 6" (15 cm) at all other locations. At other than signal controlled crossings, the crosswalk area may be marked with 12" diagonal lines at a 45° angle or transverse lines at 90°, with 24" spacing.

Channelizing lines for painted islands and ramp terminals shall be 8" (20 cm) wide. Hatch lines, when used, shall be 8" at 24" spacing.

Raised pavement markers when used for lane lines shall have the same segment and gap pattern as for painted lines. Each 15' segment shall consist of a retro-reflective marker at each end enclosing three ceramic markers, all spaced at 3.75' (1.14 m).

9-03.03 PLAN REQUIREMENTS

The signing and markings plan sheets group (TS group, see Chapter 19) of the project plans shall show the proposed markings. Details shall be included of the pavement markings at intersections, ramp terminals, pavement transitions, pedestrian crosswalks and any other location requiring special markings. The plans shall indicate the marking material, colors, widths and spacing of all markings. Reference shall be made to the applicable standard specification or special provision.

9-04 TRAFFIC SIGNALS

Traffic signals are power-operated traffic control devices used to warn or direct vehicular and/or pedestrian traffic to take some specific action. This includes traffic control signals, lane-use control signals, flashing beacons, speed control signals, railroad crossing signals and other similar devices. Traffic control signals are basically to direct traffic as to when to stop or proceed. The Department's practice on the design and use of traffic signals conforms to the standards prescribed in the MUTCD.

The design of traffic signal installations is a specialized field which should be performed by qualified traffic engineers. When traffic control signals are required, the highway designer should work closely with the traffic engineer to integrate the geometric elements of the highway design with the traffic signals design and to insure that adequate space and facilities are provided for the installation of the signal equipment.

9-04.01 WARRANTS

The warrants for the installation of traffic signals are specified in Part IV-C of the MUTCD. In the case of new construction or reconstruction of a highway facility, the traffic study data may indicate the immediate need for traffic signals. In such cases the design of the signal installations shall be incorporated into the overall design.

In many other cases, signal installation may not be initially warranted but the traffic data may show that eventual signalization of some intersections will be required. Such intersections shall be designed as if under signal control and the geometric layout should be developed in conjunction with a signalized intersection analysis. Such a procedure will help insure that an adequate number of lanes and a suitable arrangement of turning roadways is provided to meet the design traffic requirements.

Table 4-1 in Chapter 4 on "Intersections at Grade" shows suggested design hour volume combinations for which signal control should be assumed in the design or rural highways.

Guides for determining which urban intersections may warrant traffic control signal installation on the basis of estimated average daily traffic are given in Tables 9-1 and 9-2. These are based on a study made by the Department of the daily traffic volumes at existing signalized intersections. If on the basis of these guides it is determined that an urban intersection may require traffic signal control, then provisions should be made in the design to provide for the signal installation either initially or in the future.

TABLE 9-1

WARRANT 1 - MINIMUM VEHICULAR MOVEMENT

No. of Moving Lanes Each Approach		VPH on Major St. (Both Directions)	VPH on Minor St. (One Direction)	Estimated ADT	
Major St.	Minor St.			Major St.	Minor St.
1	1	500	150	9,000	2,600
2 or more	1	600	150	10,200	2,700
2 or more	2 or more	600	200	10,400	3,800
1	2 or more	500	200	8,600	3,500

NOTE: Refer to Section 4C-3 of the MUTCD (1971).

TABLE 9-2

WARRANT 2 – INTERRUPTION OF CONTINUOUS TRAFFIC

No. of Moving Lanes Each Approach		VPH on Major St. (Both Directions)	VPH on Minor St. (One Direction)	Estimated ADT	
Major St.	Minor St.			Major St.	Minor St.
1	1	750	75	13,600	1,300
2 or more	1	900	75	15,300	1,300
2 or more	2 or more	900	100	15,500	1,900
1	2 or more	750	100	11,900	1,800

NOTE: Refer to Section 4C-4 of the MUTCD (1971).

9-04.02 GEOMETRIC CONTROLS

Geometric controls which are applicable to signal installations and which may influence the design of intersections and their approaches include the following:

1. There shall be a minimum of two signal faces for through traffic at intersections.
2. Unless physically impractical, at least one and preferably both of the signal faces should be located 12 to 36 meters beyond the stop line and within a field of view of approximately 20° right and left, measured from the approach centerline of the stop bar.
3. Over the roadway mounting, either on a mast arm or span wire, is preferred. The bottom of the signal housing shall be not less than 4.6 M nor more than 5.8 M above the roadway.
4. The alignment and profile of the highway approach should permit the driver an adequate continuous view of the signal faces. The minimum distance may be calculated by the formula:

$$D = 30 + 4.6 (V - 20)$$

where D = meters

V = 85 percentile speed in mph

5. Signal supports should be located as far as practicable from the edge of the traveled way. As a minimum they should be 0.6 meters behind the curb line. Where there are no curbs they should be located at least 0.6 meter beyond the usable shoulder.
6. Ground mounted controller cabinets shall be located well away from the traveled way.

9-04.03 PLAN AND SPECIFICATION REQUIREMENTS

When signal installations are to be included in a highway project the contract documents shall include:

1. Location plan of traffic signal supports, controllers, signal heads, power source, conductor cables and conduits, detectors, and any related auxiliary equipment. This may be included in the lighting and/or signing plan. Clearances from curb or shoulder lines shall be indicated.
2. Details of supports, mast arms, support foundations, pullboxes and other appurtenances as may be necessary.

3. Initial phasing tables for each intersection.
4. Since there are no current DTPW standard specifications for traffic signal equipment, special provisions are required for each project. These special provisions shall conform to the requirements of Section 19-04.03 of Chapter 19 of this manual.

9-05 **REFERENCES**

The following is a list of selected references on traffic control devices.

1. Manual on Uniform Traffic Control Devices for Streets and Highways — Federal Highway Administration, 1971.
2. Transportation and Traffic Engineering Handbook — Institute of Traffic Engineers, 1976.
3. Traffic Control Devices Handbook — Federal Highway Administration, 1975.
4. Standard Alphabets — Federal Highway Administration, 1966.
5. Standard Highway Signs — Federal Highway Administration, 1972.
6. Manual of Traffic Engineering Studies — Institute of Traffic Engineers, 4th. Edition.
7. Capacity Analysis Techniques for Design of Signalized Intersections — Federal Highway Administration, 1967.
8. Highway Capacity Manual — Highway Research Board SR-87, 1965.
9. Roadway Delineation Systems — Highway Research Board, NCHRP Report 130, 1972.
10. Specifications for the Design and Construction of Structural Supports for Highway Signs — AASHO, 1968.