
Manual on Uniform Traffic Control Devices (MUTCD): Types of Devices

6F. TYPES OF DEVICES

The design and applications of traffic control devices used in temporary traffic control zones are described in this chapter. A traffic control device is a sign, signal, marking or other device placed on or adjacent to a street or highway (by authority of a public body or official having jurisdiction), to regulate, warn, or guide traffic. Specific crashworthiness information on devices described in this chapter can be found in the AASHTO Roadside Design Guide.⁴

⁴AASHTO, 44 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

6F-1. SIGNS

Temporary traffic control zone signs convey both general and specific messages by means of words or symbols and have the same three categories as all traffic signs: namely, regulatory signs, warning signs, and guide signs. The design for regulatory signs shall follow the standard for regulatory signs in section 2B-3. Warning signs in temporary traffic control zones shall have a black legend on an orange background. Yellow warning signs within the traffic control zone which are still applicable may remain in place. Colors for guide signs follow the standard in section 2D-3, except for special information signs as noted below in section 6F-1C.

Where the color orange is specified, fluorescent red-orange or fluorescent yellow-orange colors may be used. The fluorescent versions of orange provide higher conspicuity than standard orange, especially during twilight.

All signs used at night shall be either retroreflective, with a material that has a smooth, sealed outer surface, or illuminated to show similar shape and color both day and night. Sign illumination may be either internal or external. Roadway lighting does not meet the requirements for sign illumination.

Standard orange flags or Type B high-intensity flashing warning lights may be used in conjunction with signs. However, they must not block the sign legend.

The dimensions of signs shown herein are for standard sizes, which may be increased wherever necessary for greater legibility or emphasis. On secondary highways and city streets, smaller signs may be used if authorized by local authority. Deviations from standard sizes as prescribed herein shall be in 6-inch increments. Sign design details are contained in Standard Highway Signs.⁵

⁵Standard Highway Signs, Stock No. 950-044-00000-4. Available from the Government Printing Office, Superintendent of Documents, Washington D.C. 20402. Telephone: 202-783-3238.

As a general rule, signs should be located on the right-hand side of the roadway. When special emphasis is needed, signs may be placed on both the left and right sides of the roadway. Signs may be mounted on portable supports within the roadway itself. Signs, although ordinarily mounted on posts, may also be mounted on or above barricades.

Guidelines for height and lateral clearance of temporary post-mounted roadside signs are shown in figure VI-5. Signs erected at the side of the road should be mounted at a height of at least 7 feet, measured from the bottom of the sign to the near edge of the pavement. The height to the bottom of a secondary sign mounted below another sign may be less than the appropriate height specified above.

Methods of mounting signs other than on posts are illustrated in figure VI-6. Signs may be mounted on portable supports for short-term, short-duration, and mobile conditions (see section 6G-2). Signs mounted on Type III barriers should not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails. Unprotected sign systems should be crashworthy (refer to the Roadside 6 Design Guide, chapter Nine, for additional guidance). The bottom of signs mounted on barricades or temporary supports shall be no less than 1 foot above the traveled way.

⁶AASHTO, 44 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

For the best mobility of maintenance operations, a large sign may be mounted on a maintenance vehicle stationed in advance of the work or moving along with it. This may be either the work vehicle or the protection vehicle. A mobile sign display may be mounted on a trailer.

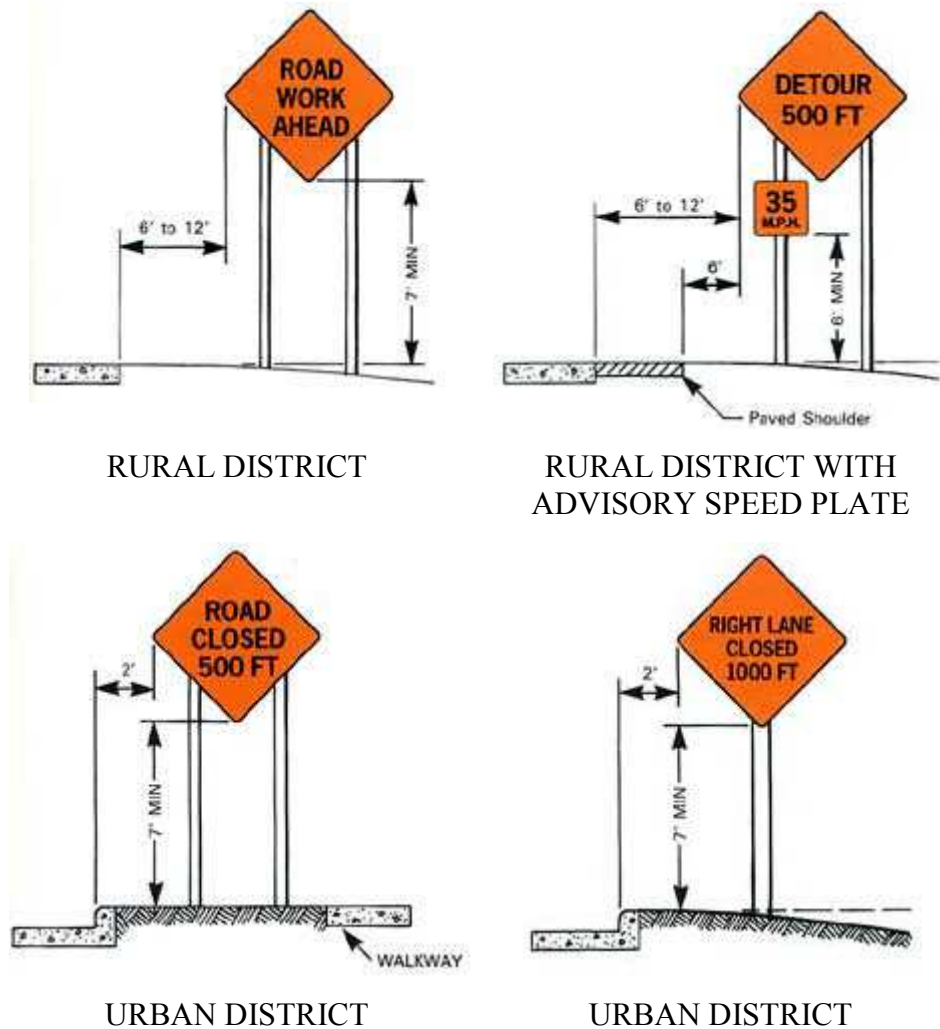
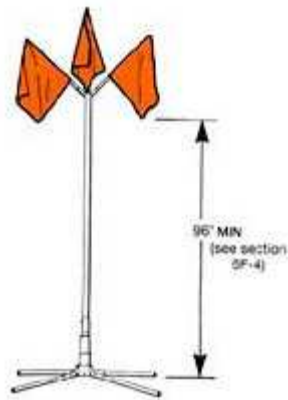


Figure VI-5. Height and lateral location of signs - Typical installation.



High Level Warning Device
(Flag Tree)



PORTABLE AND TEMPORARY MOUNTINGS

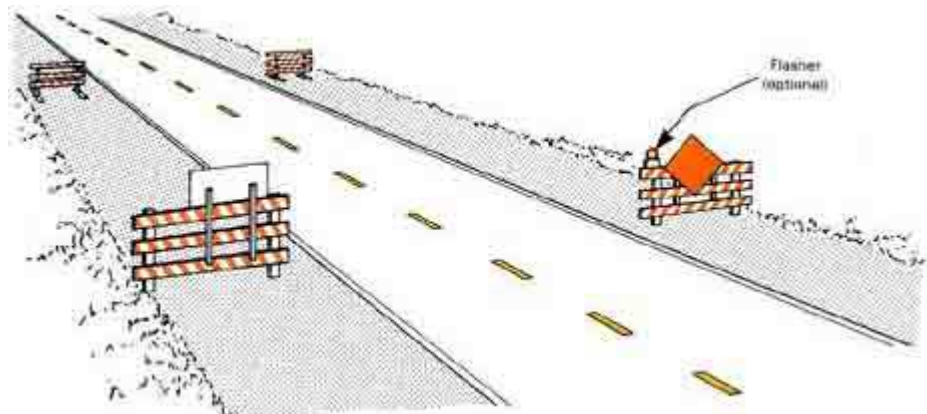


Figure V1-6. Methods of mounting signs other than on posts.

Signs used in temporary traffic control zones are moved frequently, loaded and unloaded from trucks, and in general receive much harsher treatment than permanent signs. For this reason, particular attention must be given to maintaining signs properly for cleanliness, visibility, and correct positioning. Signs that are excessively worn, scratched, bent, or that have lost a significant amount of retroreflectivity should be promptly replaced.

a. Regulatory Signs

(1) Authority

Regulatory signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements.

that would not otherwise be apparent. Because regulatory signs impose legal obligations on all drivers, they shall be authorized by the public body or official having jurisdiction and shall conform to section 2B of this manual.

(2) Design

Regulatory signs are generally rectangular, with a black legend and border on a white background. Exceptions include the STOP sign, the YIELD sign, the DO NOT ENTER sign, the WRONG WAY sign, and the one-way arrow sign. The one-way arrow sign may be either a horizontal or vertical rectangular plate. Regulatory signs are illustrated in figures VI-7a and VI-7b. Design details for all regulatory signs are given in part II of this manual and in the Standard Highway Signs book.⁷

⁷Standard Highway Signs, Stock No. 950-044-00000-4. Available from the U.S. Government Printing office, Superintendent of Documents, Washington, D.C. 20402. Telephone: 202-783-3238.



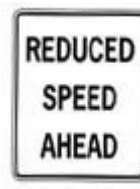
R1-1
30"x30"



R1-2
36"x36"x36"



R2-1
24"x30"



R2-5a
24"x30"



R2-5b
24"x30"



R2-5c
24"x30"



R3-1
24"x24"



R3-2
24"x24"



R3-3
24"x24"



R3-4
24"x24"



R3-5
30"x36"



R3-6
30"x36"



R3-7
30"x30"



R3-8
30"x30"



R4-1
24"x30"



R4-2
24"x30"

Figure V1-7a. Commonly used regulatory signs.

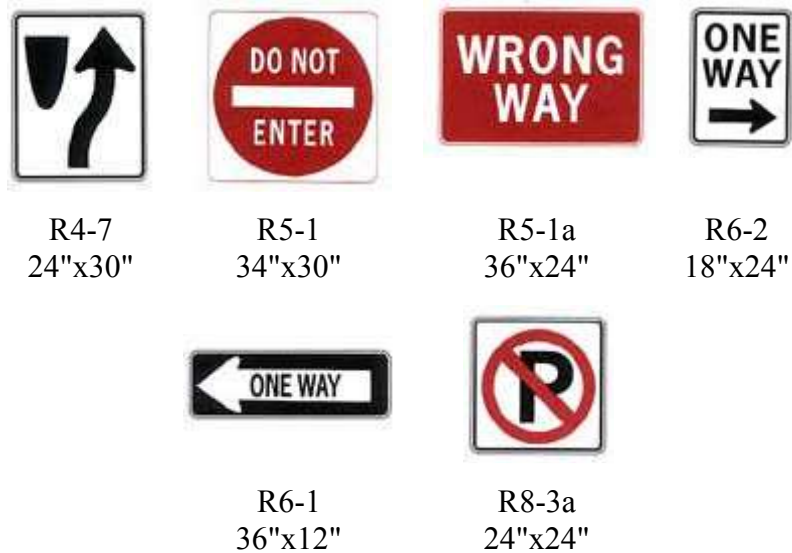


Figure VI-7b. Commonly used regulatory signs.

(3) Application

If temporary traffic control zones require regulatory measures different from those normally in effect, the existing permanent regulatory devices shall be temporarily removed or covered and superseded by the appropriate temporary regulatory signs and shall follow applicable ordinances or statutes of the jurisdiction, as well as comply with the design standards of the MUTCD.

(4) ROAD (STREET) CLOSED Sign (R11-2)

The ROAD (STREET) CLOSED sign may be used where the roadway is closed to all traffic except contractors' equipment or officially authorized vehicles and may be accompanied by appropriate detour signing. The sign shall be erected at or near the center of the roadway on or above a Type III barricade that closes the roadway (section 6F). The sign should have a minimum size of 48 inches by 30 inches. The words BRIDGE OUT or BRIDGE CLOSED may be substituted for ROAD CLOSED, where applicable. The ROAD (STREET) CLOSED sign shall not be used where traffic is maintained or where the actual closing is some distance beyond this sign.



R11-2
48" x 30"

(5) LOCAL TRAFFIC ONLY Signs (R11-3, R11-4)

The LOCAL TRAFFIC ONLY signs should be used where through traffic must detour to avoid a closing some distance beyond the sign, but where local traffic can move up to point of closure. The sign shall carry the legend ROAD CLOSED [10] MILES AHEAD-LOCAL TRAFFIC ONLY or, optionally for urban use, ROAD (STREET) CLOSED TO THRU TRAFFIC, and should be accompanied by appropriate warning and detour signing. The words BRIDGE OUT or BRIDGE CLOSED may be substituted for ROAD CLOSED where applicable.



R11-3
60"x30"



R11-4
60"x30"

(6) WEIGHT LIMIT Signs (R12-1, R12-2, R12-5)

A WEIGHT LIMIT sign shows the gross weight or axle weight that can be permitted on the roadway or bridge. restrictions should be consistent with state or local regulations and shall not be imposed without the approval of authority having jurisdiction over the highway. When weight restrictions are imposed, a marked detour should be provided for vehicles weighing more than the limit posted.



R12-1
24"x30"

R12-2
24"x30"

R12-5
30"x36"

(7) Special Regulatory Signs

Special word message regulatory signs may be needed based on an engineering analysis. The sign should conform to the requirements of color, shape, and alphabet size and series. The sign message should be brief, legible, and clear. Regulatory speed limits are established by law or regulation. Section 2B of this manual should be consulted before temporary traffic control zone regulatory speed limits are established.

b. Warning Signs

(1) Function

Temporary traffic control zone warning signs notify drivers of general or specific conditions on or adjacent to a roadway.

(2) Design and Application

With some exceptions, warning signs shall be diamond-shaped with a black symbol or message on an orange background. Mounting or space considerations may justify a change from the standard diamond shape, but such variations require prior approval of the highway authority.

Warning signs developed exclusively and used for incident management shall have an orange background. However, in emergencies, available signs having yellow backgrounds may be used if orange signs are not readily available.

The standard size for each warning sign prescribed in this section is shown with the illustration accompanying the specification. Where roadway or traffic conditions require greater emphasis, larger signs should be used, with the legend enlarged approximately in proportion to outside dimensions. Sign sizes for various type facilities can be found in the Standard Highway Signs document.⁸ (See section 1A-7.)

⁸Standard Highway Signs, Stock No. 950-044-00000-4, available from the U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402. Telephone: 202-783-3238.

Where any part of the roadway is obstructed or closed, advance warning signs are required to alert traffic well in advance of these obstructions or restrictions. These signs may be used singly or in combination. Because of their importance, they shall have a standard size of 48 inches square and shall be the standard diamond shape for warning signs, except as provided above. Signs larger than 48 inches square may be used for additional emphasis of the temporary traffic control zone.

Where speeds and volumes are moderately low, a minimum size of 36 inches square may be used for advance warning signs, if they have a minimum letter size of 5 inches.

On secondary roads or city streets where speeds are very low, signs smaller than the standard size, but not less than 30 inches square, may be used for warning signs having short word messages or clearly understood symbols.

Where distances are not shown on warning signs as part of the message, a separate panel with the distance legend may be mounted immediately below the sign on the same support.

(3) Spacing of Warning Signs Covered in Section 6H-3 Typical Application Diagrams

Where highway conditions permit, warning signs should be placed at varying distances in advance of the work area depending on the roadway type, condition, and speed. Where a series of two or more warning signs is used, the first sign to the work area should be placed approximately 200 feet away for low-speed urban streets to 1,000 feet away for expressways and freeways.

Table VI-3 presents the suggested spacing of warning signs for four general roadway types for use in section 6H-3 Typical Application Diagrams.

Table VI-3. Suggested advance warning sign spacing

Road type	Distance between signs		
	A	B	C
Urban (low speed*)	200	200	200
Urban (high speed*)	350	350	350
Rural	500	500	500
Expressway/Freeway	1,000	1,600	2,600

*Speed category to be determined by State highway agency in cooperation with local jurisdictions.

In table VI-3, the column headings "A", "B", and "C" are the dimensions for warning sign spacings for use in section 6H-3, Typical Application Diagrams. The dimensions are for marking the locations of warning signs relative to transition or point of restriction. Sign placement distances suggested in Table II-1-A are not applicable for the A, B, or C (table VI-3) distances between signs in section 6H-3.

- The "A" dimension is for the sign nearest the transition or point of restriction.
- The "B" dimension is for the next sign upstream of the transition or restriction.
- The "C" dimension is for the first sign (in a three-sign series) that the driver encounters in a temporary traffic control zone.

(4) Other Approach Warning Signs

Certain conditions require other advance warning signs, such as limited sight distance or because an obstruction requires a motorist to stop. There are no specified standards for such signs. The determination of the sign or signs used shall be based on an engineering study using the following sections as guidelines. As an alternative to a specified distance on these advance warning signs, the word AHEAD may be used.

(5) Application of Warning Signs for Maintenance, Minor Road Work, and Utility Sites

At many maintenance, minor road work, and utility sites, particularly on lightly traveled roads, the sequence of advance warning signs prescribed for major road work may not be needed. The signs described in the following sections usually provide sufficient advance warning in such situations, either by themselves or with other advance warning signs.

Maintenance or minor road work can occur within the temporary traffic control zone limits of a major project. Advance warning signs, which are needed when traffic is permitted through such zones. Maintenance and minor road work signing and traffic control should be coordinated with appropriate authorities to ensure drivers are not confused or misled by additional traffic control devices.

(6) ROAD (STREET) WORK Sign (W20-1)

The ROAD (STREET) WORK sign should be located ahead of the work space or detour, to serve as a general warning of obstructions or restrictions. It carries the legend ROAD (STREET) WORK (1,500) FT or ROAD (STREET) WORK (1/2) MILE. It may be used in conjunction with appropriate distance legends, or with other warning signs.



W20-1
48"x48"

(7) DETOUR Sign (W20-2)

The DETOUR sign is used ahead of a detour that directs traffic onto another highway in order to bypass the temporary traffic control zone. It carries the legend DETOUR [1,000] FT or DETOUR [1/2] MILE. It may be used in conjunction with appropriate legends or with other warning signs.

(8) ROAD (STREET) CLOSED Sign (W20-3)

The ROAD (STREET) CLOSED sign is used ahead of that point where a highway is closed to all traffic or to all local traffic. It carries the legend ROAD (STREET) CLOSED [1,000] FT or ROAD (STREET) CLOSED [1/4] MILE. It may be used in conjunction with appropriate legends or with other warning signs.



W20-2
48"x48"



W20-3
48"x48"

(9) ONE LANE ROAD Sign (W20-4)

The ONE LANE ROAD sign should be used ahead of that point where traffic in both directions must use a common single lane. It carries the legend ONE LANE ROAD [1,000] FEET or ONE LANE ROAD [1/4] MILE. The sign must be used in conjunction with appropriate legends or with other warning signs.

If the affected one-lane roadway is not visible from one end to the other, or if the traffic is such that simultaneous arrivals at both ends occur frequently, flagging procedures or signal control should be used to control alternate traffic flows.

(10) LANE CLOSED Sign (W20-5)

The LANE CLOSED sign is used before that point where one lane of a multiple-lane roadway is closed. It carries the legend RIGHT (LEFT) LANE CLOSED [1,000] FEET or RIGHT (LEFT) LANE CLOSED [1/4] MILE. The sign must be used in conjunction with appropriate legends or with other warning signs.



W20-4
48"x48"



W20-5
48"x48"

(11) FLAGGER Sign (W20-7a)

The FLAGGER symbol sign (W20-7a) should be used before any point where a flagger is stationed to control traffic. A distance legend may be displayed on a supplemental plate below the symbol sign. The sign may be used in conjunction with appropriate legends or with other warning signs, such as W20-7b, BE PREPARED TO STOP.

The FLAGGER word message sign (W20-7) with distance legends may be substituted for the flagger symbol sign (W20-7a).

The FLAGGER sign shall be removed, covered, or turned to face away from traffic when the flagger is not at the station.



W6-3
48"x48"

(12) TWO-WAY TRAFFIC Sign (W6-3)

When one roadway of a normally divided highway is closed, the TWO-WAY TRAFFIC sign should be used at the beginning of the closing and at intervals to remind drivers that they are on a two-way highway with opposing traffic.



W20-7a
48" x 48"
SUPPLEMENTAL PLATE
24" x 18"

(13) WORKERS Sign (W21-1a)

A WORKERS sign may be used to alert drivers of workers in or near the roadway. The W21-1 WORKERS work sign message sign may be used as an alternative to the W21-1a workers symbol sign.

(14) FRESH OIL Sign (W21-2)

The FRESH OIL (TAR) sign should be placed ahead of the last exit to warn drivers that resurfacing has rendered pavement temporarily slippery and that splashing may occur.

(15) ROAD MACHINERY Sign (W21-3)

The ROAD MACHINERY sign may be used to warn of heavy equipment operating in or next to the roadway.

(16) SHOULDER WORK Sign (W21-5)

The SHOULDER WORK sign may be used to warn of maintenance, reconstruction, or utility operations on the shoulder, where the traveled way is unobstructed.

(17) SURVEY CREW Sign (W21-6)

The SURVEY CREW sign may be used to warn of survey crews working in or next to the roadway.





(18) Signs for Blasting Areas

Radio frequency (RF) energy can cause the premature firing of electric detonators (blasting caps) used in temporary traffic control zones or blasting zones. Drivers must be warned to turn off mobile radio transmitters and cellular telephones. The Institute of Makers of Explosives publishes information on this hazard and guidelines for safe operations.⁹

⁹Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps), Safety Library Publication No. 20. Institute of Makers of Explosives, 1120 19th St., N.W. Suite 200, Washington, D.C. 20036-3605. Telephone 202-429-9280.

A sequence of signs should be used to direct operators of mobile radio equipment to turn off transmitters in a blasting area. A minimum safe distance of 1,000 feet should be used for warning sign placement. These signs shall be prominently displayed and covered or removed when there are no explosives in the area or the area is otherwise secured.

(18a) BLASTING ZONE Sign (W22-1)

The BLASTING ZONE AHEAD sign should be used in advance of any work space where explosives are being used. The TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES and END BLASTING ZONE signs shall be used in sequence with this sign.

(18b) TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES Sign (W22-2)

The TURN OFF 2-WAY RADIO AND CELLULAR TELEPHONES sign should follow the BLASTING ZONE AHEAD sign and is placed at least 1,000 feet before the beginning of the blasting zone.

(18c) END BLASTING ZONE Sign (W22-3)

The END BLASTING ZONE sign shall be placed a minimum of 1,000 feet past the blasting zone, either with or

preceding the END ROAD WORK sign.



W22-1
48"x48"



W22-2
42"x36"



W22-3
42"x36"

(19) SHOULDER DROP

The SHOULDER DROP-OFF sign should be used when a shoulder drop-off exceeds 3 inches in height and is not protected by a portable barrier.



W8-9a
36"x36"
W8-9a
36"x36"

(20) UNEVEN LANES Sign (W8-11)

The UNEVEN LANES sign should be used during operations that create a difference in elevation between adjacent lanes.



W8-11
36"x36"
W8-11
36"x36"

(21) NO CENTER STRIPE Sign (W8-12)

The NO CENTER STRIPE sign should be used when the work obliterates the center stripe. This sign should be placed at the beginning of the zone and repeated at 2-mile intervals in long zones to remind the motorist. It should also be placed at major connections, traffic generators, and/or at appropriate intervals as determined by the engineer, to advise motorists entering within the zone.



W8-12
36"x36"

W8-12
36"x36"

(22) Other Warning Signs

The signs pictured in figures VI-8a, VI-8b, and VI-8c may also be used to provide sufficient advance warning, either themselves or with other advance warning signs.

Besides the warning signs specifically related to temporary traffic control zones, several other warning signs, many of which have been standardized in part II of this MUTCD, may apply in these zones. When used in temporary traffic control zones, warning signs shall have black legends on an orange background.

(23) Advisory Speed Plate (W13-1)

In combination with a warning sign, an advisory speed plate may be used to indicate a recommended safe speed through the temporary traffic control zone. When used with orange temporary traffic control zone signs, this plate shall have a black legend and border on an orange background. It shall not be used with any sign other than a warning sign, nor shall it be used alone. The sign shall be at least 24 inches square in size when used with a sign 36 inches square or larger. Except in emergencies, an advisory speed plate (W13-1) shall not be mounted until the recommended speed is determined by the highway authority.



W13-1
18"x18"
24"x24"

W13-1
18"x18"
24"x24"



W1-1R



W1-2R



W1-3R



W1-4aR

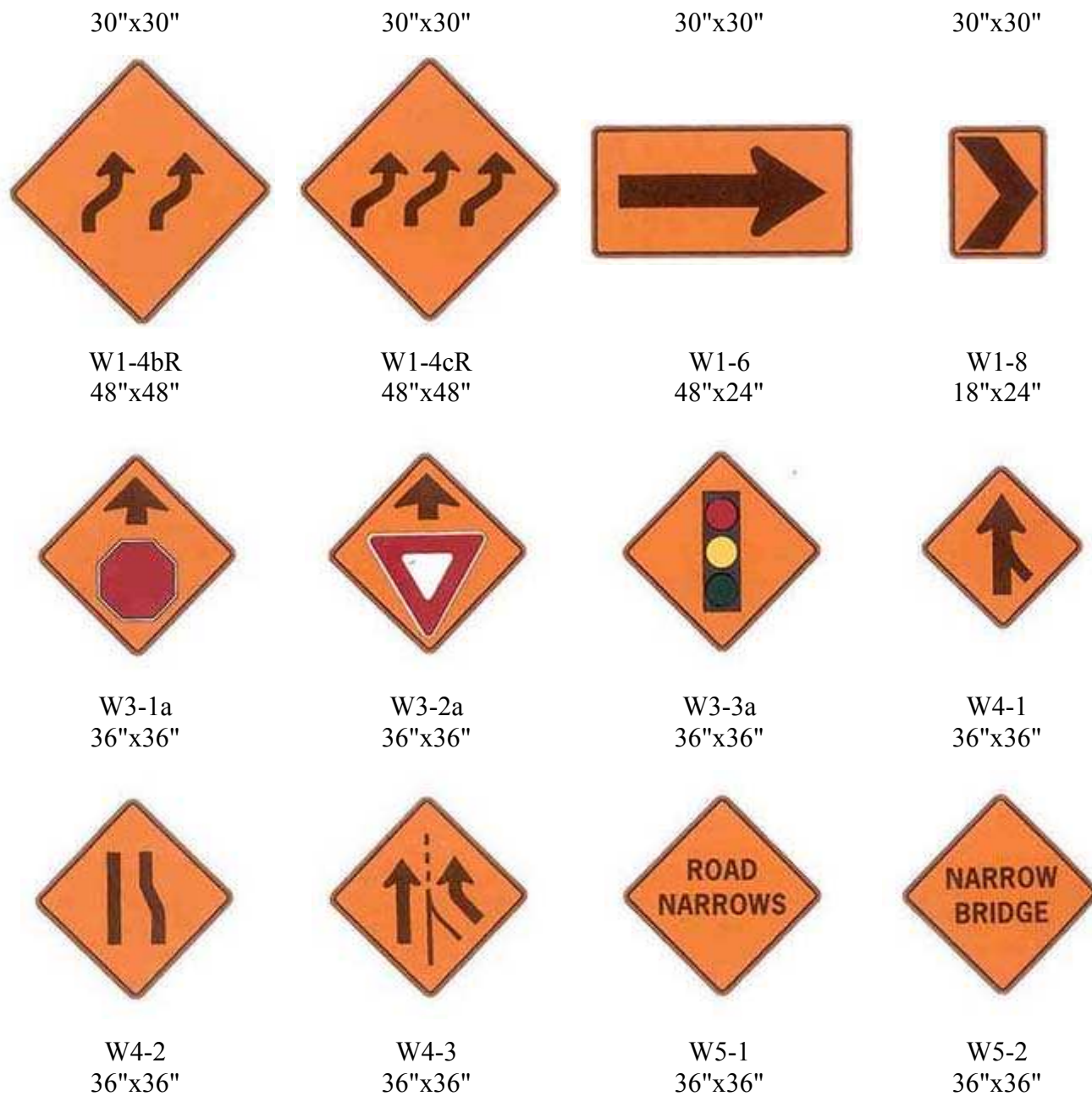


Figure VI-8a. Warning signs used in temporary traffic control zones.



W5-2a
36"x36"



W-3
36"x36"



W6-1
36"x36"



W6-2
36"x36"



W7-1
30"x30"



W8-1
30"x30"



W8-2
30"x30"



W8-3
30"x30"



W8-3a
36"x36"



W8-4
30"x30"



W8-5
30"x30"



W8-6
30"x30"



W8-7
30"x30"



W8-8
30"x30"



W8-9
30"x30"



W8-9a
36"x36"

Figure VI-8b. Warning signs used in temporary traffic control zones.

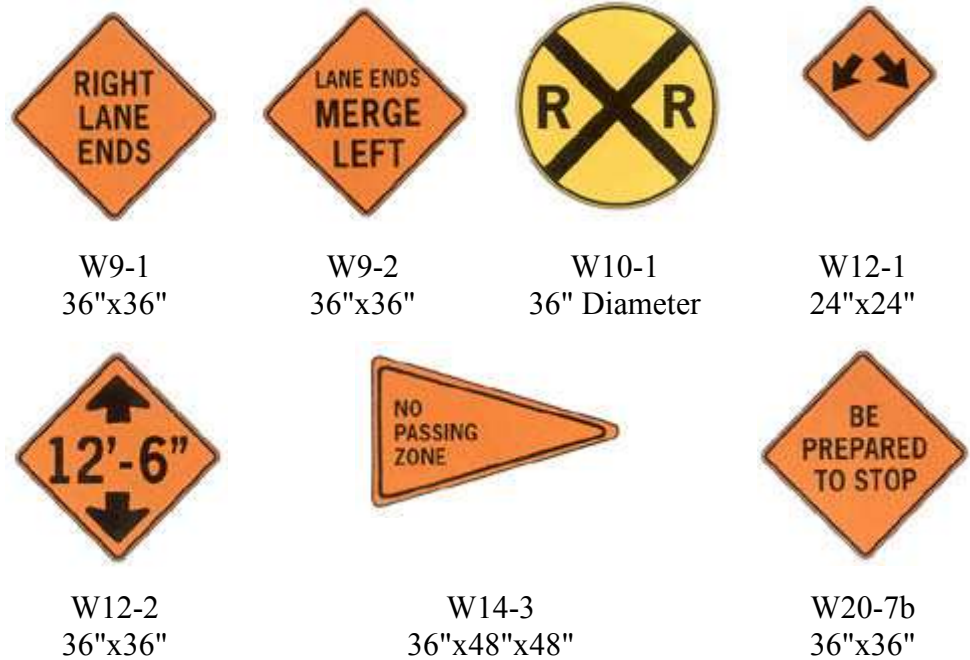


Figure VI-8c. Warning signs used in temporary traffic control zones.

c. Guide Signs

(1) Function and Design of Guide Signs

Guide signs are essential along streets and roadways to give drivers information that will help them in the most direct manner possible. The design of guide signs is given in part II of this manual.

The following guide signs are required at temporary traffic control zones:

(a) Standard route markings, where temporary route changes are necessary.

(b) Directional signs such as motorist service signing, recreational and cultural interest area signs, tourist-oriented directional signs (TODS), civil defense signing, and street name signs. when used with detour routing, these signs have a black legend on an orange background.

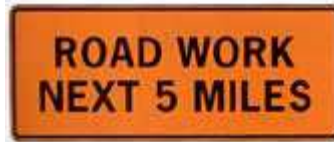
(c) Special information signs relating to work being done. These signs shall have a black legend on an orange background.

(2) Length of Work Sign (G20-1)

The Length of Work sign should be erected in advance of any temporary traffic control zone of more than 2 miles length; it carries the legend ROAD WORK NEXT [5] MILES. The distance shall be stated to the nearest whole mile. The sign may be mounted on a Type III barricade. The sign may also be used for jobs of shorter length.

(3) END ROAD WORK Sign (G20-2A)

The END ROAD WORK sign should be placed about 500 feet past the work area. The sign may be erected on top of a warning sign facing the opposite direction of traffic or on the back of a Type III barricade.



G20-1
60"x24"



G20-2A
48"x24"

(4) DETOUR signs and Markers (M4-8, -8a, -8b, -9, and -10)

The DETOUR ARROW sign (M4-10) should be used where a detour route has been established because of the closure of a street or highway to through traffic. The sign should normally be mounted just below the ROAD CLOSED (R11-3, or R11-4) sign. The DETOUR ARROW sign has a horizontal arrow pointed to the right or left, as required.

Each detour shall be adequately marked with standard temporary route markers and destination signs. The DETOUR marker sign (M4-8), mounted at the top of a route marker assembly, marks a temporary route that branches from a highway, bypasses a section closed by a temporary traffic control zone, and rejoins the highway beyond the temporary traffic control zone.

The DETOUR sign (M4-9) should be used for unnumbered highways, for emergency situations, for periods of short durations, or where, over relatively short distances, traffic may be guided along the detour and back to the desired highway without route markers. A street name sign may be placed above or incorporated in the DETOUR sign to indicate the name of the street being detoured.

The END DETOUR sign (M4-8a or M4-8b) may be used to indicate that the detour has ended. When the END DETOUR sign is used on a numbered highway, the sign should be mounted above a marker after the end of the



M4-8
24"x12"



M4-8a
24"x18"



M4-8b
24"x12"



M4-9R
30"x24"



M4-10R
48"x18"

(5) PILOT CAR Sign (G20)

The Pilot Car sign shall be mounted in a conspicuous position on the rear of a vehicle used for guiding one-way traffic through or around a work space. The legend shall be PILOT CAR-FOLLOW ME. A flagger shall be stationed on the approach to the activity area to stop traffic until the pilot car is available.



G20-4
36"x18"
G20-4
36"x18"

6F-2. PORTABLE CHANGEABLE MESSAGE SIGNS

a. Design

Portable Changeable Message Signs (PCMS) are traffic control devices with the flexibility to display a variety of messages to fit the needs of road and street authorities. Each message consists of one or more displays. Portable Changeable Message signs are used most frequently on high density, urban freeways, but have applications on all types of highways where highway alignment, traffic routing problems or other pertinent conditions require advance warning and information.

(1) Components: The components of a PCMS should include message sign panel, control systems, power source, mounting and transporting equipment.

(a) Message Sign Panel

PCMS cannot always conform to the exact sign shape, color, and dimensions specified in these standards. PCMS should subscribe to the principles established in the manual, and to the extent practicable, with the design (i.e., color, letter size and shape, and borders) and applications prescribed herein. The message sign panel can vary in size and consist of one, two, or three lines. High-density urban freeways typically use three lines of eight characters per line. Each character module shall use, as a minimum, a five wide-pixel by seven high-pixel matrix. The front face of the sign should be covered with a protective material. Element colors for warning messages should be black on a yellow or orange background; for guide messages, white on a green background or black on an orange background; and for regulatory messages, black on a white background. Color reversals are also acceptable.

The signs should be visible from 1/2 mile under ideal day and night conditions. Each sign message should be legible from all lanes, from the sign up to a minimum of 650 feet. In the field, the PCMS should be sited and aligned to optimize driver performance. The message panel should have adjustable flash rates, so that the entire message can be read at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

Under low light level conditions, the sign shall automatically adjust its light source so as to meet the legibility requirements and not impair the drivers, vision.

(b) Control System

The control system shall include the following features:

- A display screen upon which messages can be reviewed before display on the message sign.
- A capability to provide an automatic programmed default message if power failure occurs.
- A backup battery to maintain memory when power is unavailable.

(c) Power Source

The PCMS shall be equipped with a power source and a battery back-up to provide continuing operation when power is

of the primary power source occurs.

(d) Mounting

The mounting of the PCMS shall be such that the bottom of the message sign panel shall be a minimum of 7 feet above the roadway when it is in the operating mode.

b. Application

PCMS have a wide variety of applications in temporary traffic control zones, including roadway or ramp closure, accident or emergency incident management, width restriction information, advisories on roadwork scheduling, management and diversion, warning of adverse conditions, and operation control. PCMS should be used with conventional signs, pavement markings, and lighting.

The primary purpose of PCMS in temporary traffic control zones is to advise the driver of unexpected traffic and routing situations. Some typical applications include the following:

- Where speed of traffic is expected to drop substantially
- Where significant queuing and delays are expected
- Where adverse environmental conditions are present
- Where there are changes in alignment or surface conditions
- To provide advance notice of ramp, lane, or roadway closures
- For accident or incident management

PCMS should be placed to be visible from at least 1/2 mile under both day and night conditions. Placement in advance of the temporary traffic control zone or incident should, as much as possible, take into account the following factors:

- PCMS will typically be placed in advance of any other temporary traffic control zone signing and should not replace any required signing.
- Where used for route diversion, PCMS should be placed far enough in advance of the work site to give traffic ample opportunity to exit the affected highway.
- PCMS are normally placed on the shoulder of the roadway. However, if practical, placement further from the traveled lane is desirable.
- When two signs are needed to communicate multiple messages, they should be placed on the same side of the roadway, separated by at least 1,000 feet.

PCMS messages should be readily understood by drivers and thus will allow them adequate time to react. Messages should be designed taking into account the following factors:

- No more than two displays should be used within any message cycle.
- Each display should convey a single thought.
- Messages should be as brief as possible.
- When abbreviations are used, they should be easily understood.
- The entire message cycle should be readable at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.
- Messages shall not scroll horizontally or vertically across the face of the sign.

6F-3. ARROW DISPLAYS

An arrow display is a sign with a matrix of elements. The matrix, capable of either flashing or sequential display, is intended to provide additional warning and directional information to assist in merging and controlling traffic through or around a temporary traffic control zone. An arrow display should be used in combination with appropriate signs, barricades, or other traffic control devices.

a. Arrow Display Specifications

Arrow displays shall meet the size and other specifications of figure VI-9. A PCMS may be used to simulate an arrow display.

Type A arrow displays are appropriate for use on low-speed urban streets. Type B are appropriate for intermediate speed facilities and for maintenance or mobile operations on high-speed roadways. Type C arrow displays are intended to be used on high-speed, high-volume traffic control projects.

An arrow display shall be rectangular, of solid appearance, and finished in nonreflective black. The panel shall be mounted on a vehicle, a trailer, or other suitable support. A vehicle-mounted panel should be provided with 5 rear view mirrors. Minimum mounting height should be 7 feet from the roadway to the bottom of the panel, except on vehicle-mounted panels, which should be as high as practicable.

An arrow display shall have the following mode selections:

- A flashing arrow, sequential arrow, or sequential Chevron mode
- Flashing Double Arrow mode
- Flashing Caution mode

Arrow display elements shall be capable of a minimum 50 percent dimming from their full-rated lamp voltage. Full lamp voltage should be used for day, and dimmed mode shall be used for night.

The arrow display shall have suitable elements capable of the various operating modes. If an arrow panel consists of a bulb matrix is used, the elements should be recess-mounted or equipped with an upper hood of not less than 180 degrees. The color presented by the elements shall be yellow.

Minimum element "on time" shall be 50 percent for the flashing mode and equal intervals of 25 percent for each sequential phase. The flashing rate shall be no fewer than 25 nor more than 40 flashes per minute.

b. Arrow Display Application

An arrow display in the arrow or chevron mode may be used for stationary or moving lane closures. An arrow display in the caution mode shall be used only for shoulder work, blocking the shoulder, or roadside work near the shoulder.

For a stationary lane closing, the arrow display should be located on the shoulder at the beginning of the taper.

Where the shoulder is narrow, the arrow display should be located in the closed lane. If arrow displays are used on multiple lanes are closed in tandem, the preferred position for additional arrow displays is in the closed lane at the

of the merge taper. Under various situations, such as for narrow shoulders, placement may be in the middle or at the end of the merge taper but always behind the channelizers. The panel shall be located behind any channelizing device to transition traffic from the closed lane.






Operating Mode	Panel Display		
I. At least one of the three following modes shall be provided:	(Right shown; left similar)		
Flashing Arrow	 Move/ Merge Right		
Sequential Arrow	 Move/ Merge Right		
Sequential Chevron	 Move/ Merge Right		
II. The following mode shall be provided: Flashing Double Arrow	 Move/Merge Right or Left		
III. The following shall be provided: Flashing Caution *Element layout for Type C Panel shown	 Caution		
Panel Type	Minimum Size (inches)	Minimum Legibility Distance (miles)	Minimum Number of Elements
A	48 x 24	1/2	12
B	60 x 30	3/4	13
C	96 x 48	1	15

Figure VI-9. Advance Warning Arrow Display Specifications.

For mobile operations where a lane is closed, the arrow display should be located to provide adequate separation of the work operation to allow for appropriate reaction by approaching drivers. A vehicle displaying an arrow display should be equipped with appropriate signing and/or lighting.

An arrow display shall not be used on a two-lane, two-way roadway for temporary one-lane operation.

An arrow display shall not be used on a multilane roadway to laterally shift all lanes of traffic, because unnecessary lane changing may result.

6F-4. HIGH-LEVEL WARNING DEVICES

The high-level warning device (flag tree) may supplement other traffic control devices in temporary traffic control zones. It is designed to be seen over the top of vehicles. A typical high-level warning device is shown in figure V-1.

A high-level warning device shall consist of a minimum of two flags with or without a Type B, high-intensity, flashing warning light. The distance from the roadway to the bottom of the lens of the light and to the lowest point of the material shall be no less than 8 feet. The flags shall be 16 inches square or larger and shall be orange or fluorescent versions of orange in color. An appropriate warning sign may be mounted below the flags.

High-level warning devices are most commonly used in urban high-density traffic situations to warn motorists of temporary operations.

6F-5. CHANNELIZING DEVICES

a. General

The function of channelizing devices is to warn and alert drivers of conditions created by work activities near the traveled way, to protect workers in the temporary traffic control zone, and to guide drivers and pedestrians safely. Channelizing devices include but are not limited to cones, tubular markers, vertical panel markers, drums, barricades, temporary raised islands, and barriers.

Devices used for channelization should provide for smooth and gradual traffic movement from one lane to another, onto a bypass or detour, or to reduce the width of the traveled way. They may also be used to separate traffic from the work space, pavement drop-offs, pedestrian paths, or opposing directions of traffic.

Channelizing devices should be constructed and ballasted to perform in a predictable manner when inadvertently struck by a vehicle. If struck, they should yield or break away, and fragments or other debris from the device should not penetrate the passenger compartment of the vehicle or be a potential hazard to workers or pedestrians in the immediate area.

Spacing of channelizing devices should not exceed a distance in feet equal to the speed when used for tangent channelization, and a distance in feet of twice the speed when used for tangent channelization.

Warning lights on channelizing devices. Consideration should be given to fog or snow areas, severe road curvature, and usually cluttered environments. Flashing warning lights may be placed on channelizing devices.

used singly or in groups to mark a spot condition. Warning lights on channelizing devices used in a series shall be steady-burn.

The retroreflective material used on channelizing devices shall have a smooth, sealed outer surface.

Channelizing devices are elements in a total system of traffic control devices for use in temporary traffic control zones. These elements shall be preceded by a subsystem of warning devices that are adequate in size, number, and placement for the type of highway on which the work is to take place. Standard designs of channelizing devices are shown in figure VI-10.

The name and telephone number of the agency, contractor, or supplier may be shown on the non-retroreflective surface of all channelizing devices. The letters and numbers shall be a non-retroreflective color and not less than 1/2 inches in height.

Particular attention should be given to assuring that channelizing devices are maintained and kept clean, and properly positioned at all times. Devices shall be replaced that are damaged and have lost a significant amount of their retroreflectivity and effectiveness.

b. Cones

(1) Cone Design

Cones shall be predominantly orange, fluorescent red-orange, orange, not less than 18 inches in height, or fluorescent yellow and shall be made of a material that can be struck without damaging vehicles on impact. Cones shall be a minimum of 28 inches in height when they are used on freeways and other high-speed highways, on all highways during nighttime, or whenever more conspicuous guidance is needed.

For nighttime use, cones shall be retroreflective or equipped with lighting devices for maximum visibility. Retroreflection of 28-inch or larger cones shall be provided by a white band 6 inches wide, no more than 3 to 4 inches from the top of the cone, and an additional 4-inch-wide white band a minimum of 2 inches below the 6-inch band.

(2) Cone Application

Traffic cones are used to channelize traffic, divide opposing traffic lanes, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate short-duration maintenance and utility work.

Steps should be taken to ensure that cones will not be blown over or displaced by wind or moving traffic. Cones shall be doubled up to increase their weight. Some cones are constructed with bases that can be filled with ballast. Other cones have special weighted bases, or weights such as sandbag rings that can be dropped over the cones and onto the base to provide added stability. Ballast, however, should not present a hazard if the cones are inadvertently struck.

c. Tubular Markers

(1) Design

Tubular markers shall be predominantly orange, not less than 18 inches high, minimum 2 inches wide when facing traffic, and made of a material that can be struck without damaging impacting vehicles. Tubular markers shall be a minimum of 28 inches high when used on freeways and other high-speed highways, on all highways during nighttime.

or whenever more conspicuous guidance is needed.

For nighttime use, tubular markers shall be retroreflective. Retroreflection of tubular markers shall be provided by 3- inch-wide white bands placed a maximum of 2 inches from the top, with a maximum of 6 inches between the

(2) Application

Tubular markers have less visible area than other devices and should be used only where space restrictions do not allow for the use of other more visible devices. They may be used effectively to divide opposing lanes of traffic, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate edge of pavement dropoff where other limitations do not allow the use of larger devices.

Steps should be taken to assure that tubular markers will not be blown over or displaced by traffic by either affixing them to the pavement with anchor bolts or adhesive, using weighted bases, or weights that can be dropped over the tubular markers and onto the base to provide added stability. Ballast, however, should not be allowed to present a hazard if the tubular markers are inadvertently struck. If a noncylindrical device is used, and it could be displaced to a width less than the minimum facing traffic, it shall be attached to the pavement to ensure that the width facing traffic meets the minimum requirements.

d. Vertical Panels

(1) Design

Vertical panels shall be 8 to 12 inches wide and at least 24 inches high. They shall have orange (fluorescent red-orange or fluorescent yellow-orange) and white stripes, and be retroreflective. Panel stripe widths shall be 6 inches, except where panel heights are less than 36 inches, when 4-inch stripes may be used. If used for two-way traffic, back-to-back panels shall be used.

Markings for vertical panels shall be alternating orange and white retroreflectorized stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). Vertical panels used on expressways, freeways, and other high speed roadways shall have a minimum of 270 square inches of retroreflective area facing traffic.

(2) Application

Vertical panels may be used to channel traffic, divide opposing lanes of traffic, divide traffic lanes or in place of other barricades where space is limited.

e. Drums

(1) Design

Drums used for traffic warning or channelization shall be constructed of lightweight, flexible, and deformable material and be a minimum of 36 inches in height; and have at least an 18- inch minimum width, regardless of orientation. Non-retroreflective drums shall not be used. The markings on drums shall be horizontal, circumferential, alternating orange and white retroreflective stripes 4 to 6 inches wide. Each drum shall have a minimum of two orange and two white stripes. Non-retroreflective spaces between the horizontal orange and white stripes, shall not exceed 2 inches wide. Drums shall have closed tops that will not allow collection of roadwork or other debris.

(2) Application

Drums are most commonly used to channelize or delineate traffic flow but may also be used singly or in groups

specific locations. Drums are highly visible and have good target value, given the appearance of being formidable obstacles and, therefore, command the respect of drivers. They are portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but are generally used in situations where they will remain in place for a prolonged period.

Drums should not be weighted with sand, water, or any material to an extent that would make them hazardous to motorists, pedestrians, or workers. When they are used in regions susceptible to freezing, they should have drain holes in the bottom so water will not accumulate and freeze, causing a hazard if struck by a motorist. Ballast shall be placed on top of drum.

f. Barricades

(1) Design

A barricade is a portable or fixed device having from one to three rails with appropriate markings. It is used to control traffic by closing, restricting, or delineating all or a portion of the right-of-way.

Barricades shall be of three types: Type I, Type II, or Type III.

Stripes on barricade rails shall be alternating orange and white retroreflective stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). The stripes shall be six inches wide, except where rail lengths are less than 36 inches, when 4-inch-wide stripes may be used. The minimum rail length is 24 inches. Barricades used on expressways, freeways, and other high-speed roadways shall have a minimum of 270 inches of retroreflective area facing traffic.

Where a barricade extends entirely across a roadway, the stripes should slope downward in the direction which traffic must turn. Where both right and left turns are provided, the stripes may slope downward in directions from the center of the barricade or barricades. Where no turns are intended, the stripes should slope downward toward the center of the barricade or barricades.

Barricade rails should be supported in a manner that will allow them to be seen by the motorist and provide a stable support not easily blown over by the wind or traffic. For Type I barricades, the support may include unstriped horizontal panels necessary to provide stability.

Barricades are located adjacent to traffic and are therefore subject to impact by errant vehicles. Because of their vulnerable position and the hazard they could create, they should be constructed of lightweight materials and have no rigid stay bracing for A-frame designs.

On high-speed expressways or in other situations where barricades may be susceptible to overturning in the wind, sandbags should be used for ballasting. Sandbags may be placed on lower parts of the frame or struts to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted with heavy objects such as rocks or chunks of concrete.

(2) Application

Type I or Type II barricades are intended for use in situations where traffic is maintained through the ten-foot traffic control zone. They may be used singly or in groups to mark a specific condition, or they may be used in a series for channelizing traffic. Type I barricades normally would be used on conventional roads or urban streets and arterials. Type II barricades have more retroreflective area and are intended for use on expressways and freeways or other high-speed roadways.

Type III barricades used at a road closure may extend completely across a roadway or from curb to curb. If provision is made for access of authorized equipment and vehicles, the responsibility for the Type III barricade should be assigned to a person to ensure proper closure at the end of each work day.

When a highway is legally closed but access must still be allowed for local traffic, the Type III barricade should not be extended completely across a roadway. A sign with the appropriate legend concerning permissible access for local traffic shall be mounted. (See section 6F-1.a.5.)

Signs may be erected on barricades, particularly those of the fixed type, that offer a most advantageous field of view for this purpose. The ROAD CLOSED and DETOUR ARROW signs, and the LARGE ARROW warning sign, for example, can be mounted effectively on or above the barricade that closes the roadway.

g. Portable Barriers

The need for portable barriers should be determined by analysis and the protective requirements of the engineer at an location, not the channelizing needs. They should be designed according to chapter 9 of the AASHTO Roadside Design Guide." ¹⁰

¹⁰AASHTO, 444 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

When serving the additional function of channelizing traffic, the barrier taper shall meet standard channelizing taper lengths. The channelizing barrier shall be supplemented by standard delineators, channelizing devices, and pavement markings. Channelizing barriers should not be used for a merging taper except in low-speed urban areas.

h. Temporary Raised Islands

The temporary raised island should only be used on roadways with speeds of 45 mph or less except when otherwise recommended by an engineering study.

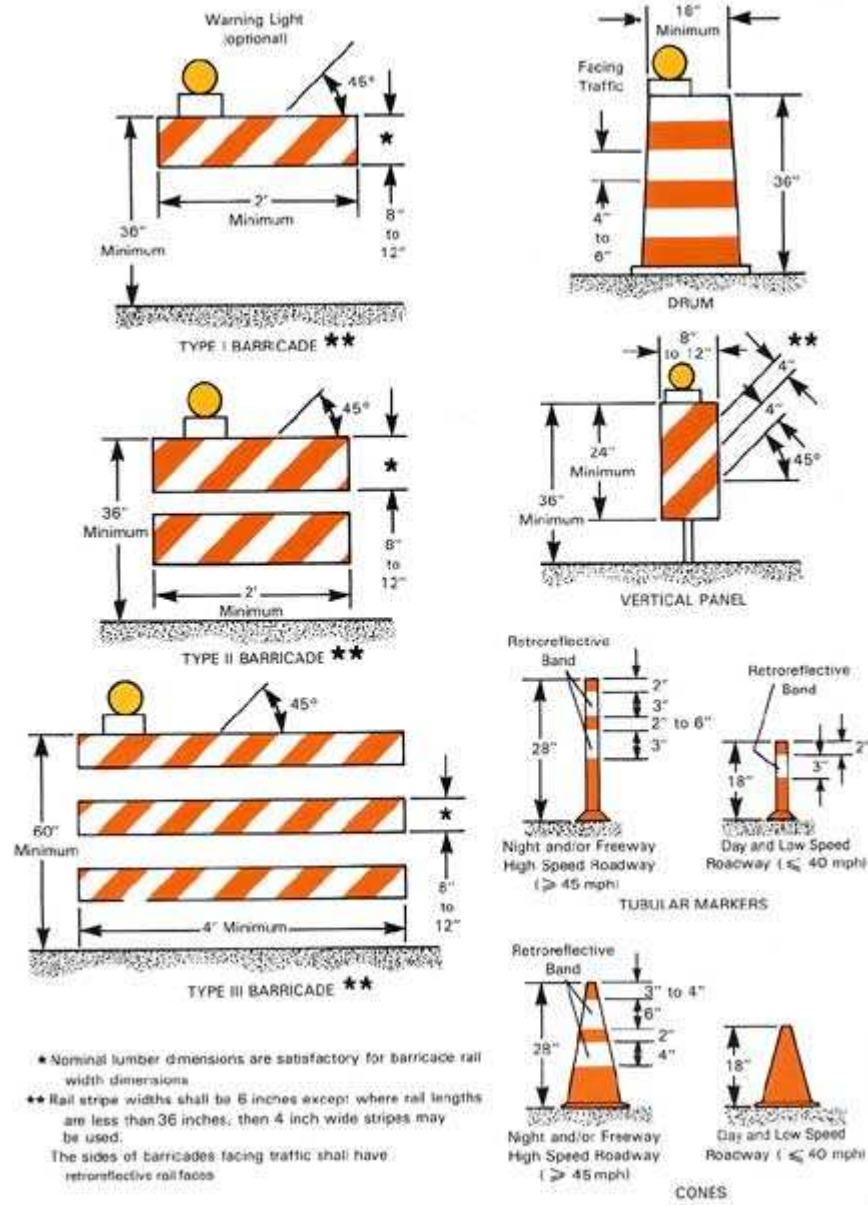
Temporary raised islands, not to exceed 4 inches in height, may be used to supplement channelizing devices and pavement markings to separate traffic flows in two-lane, two-way operations (TLTWO). Pavement edge devices may be placed on the island itself. Islands may also have application in other than TLTWO where physical separation of traffic from the temporary traffic control zone is not required.

One type of temporary raised island is 4 inches high by 18 inches wide and has rounded or chamfered corners. They may be constructed of Portland cement concrete or bituminous concrete. They should be designed according to chapter 9 of the AASHTO Roadside Design Guide." ¹¹

¹¹AASHTO, 444 North Capitol Street, N.W. , Suite 225, Washington, D.C. 20001.

i. Other Channelizing Devices

Channelizing devices, other than those specified above, may be required for special situations based on an engineering study. Such devices should conform to the general size, color, stripe pattern, retroreflection, placement characteristics established for standard devices.



j.

* Nominal lumber dimensions are satisfactory for barricade rail width dimensions

** Rail stripe widths shall be 6 inches except where rail lengths are less than 36 inches, then 4 inch wide stripes

used.

The sides of barricades facing traffic shall have retroreflective rail faces.

Figure VI-10. Channelizing Devices.

6F-6. MARKINGS

a. Pavement Marking Applications

Adequate pavement markings shall be maintained along paved streets and highways in temporary traffic zones. Obliterated markings shall be unidentifiable as pavement markings under day or night, wet or dry conditions. The work should be planned and staged to provide the best possible conditions for the placement and removal of the pavement markings.

It is intended, to the extent possible, that motorists be provided markings within a work area comparable to markings normally maintained along adjacent roadways, particularly at either end of the work area. The following guidelines set forth the level of markings and delineation for various work area situations.

- (1) All markings shall be in accordance with part III A and part III B, except as indicated under 6F-6b (Interim Markings) of this manual.
- (2) Markings shall be maintained in long-term stationary work areas and shall match and meet the markings in place at both ends of the work area.
- (3) Markings shall be placed, along the entire length of any surfaced detour or temporary roadway, such as a detour or roadway is opened to traffic.
- (4) Centerline/lane lines should be placed, replaced, or delineated where appropriate before the roadway is opened to traffic.
- (5) Markings should be provided in intermediate-term stationary work areas, to the extent practicable.
- (6) In any work area where it is not practical to provide a clear path by markings, appropriate warning signs, channelizing devices, and delineation shall be used to indicate the required vehicle paths.

All markings and devices used to delineate vehicle and pedestrian paths shall be carefully reviewed during both daytime and nighttime periods to avoid inadvertently leading drivers or pedestrians from the intended path.

Proper pavement marking obliteration leaves a minimum of pavement scars and completely removes old marking materials.

Obliterated markings shall be unidentifiable as pavement markings under day or night, wet or dry conditions. Overlaying existing stripes with black paint or asphalt does not meet the requirements of covering, removing, or obliteration; however, the use of removable, nonreflective, preformed tape is permitted where markings must be covered temporarily.

b. Interim Markings

Interim pavement markings are those that may be used until it is practical and possible to install pavement markings that meet the full MUTCD standards for pavement markings. Normally, it should not be necessary to leave interim pavement markings in place for more than 2 weeks. All interim pavement markings, including pavement markings for no-passing zones, shall conform to the requirements of sections 3A and 3B with the following exceptions:

(1) All interim broken-line pavement markings shall use the same cycle length as permanent markings and shall be at least 4 feet long, except that half-cycle lengths with a minimum of 2-foot stripes may be used for roadways with severe curvature. (See section 3A-6.) This applies to white lane lines for traffic moving in the same direction and yellow center lines for two-lane roadways when it is safe to pass.

(2) For those interim situations of 3 calendar days or less for a two- or three-lane road, no-passing zones may be identified by using signs rather than pavement markings. (See sections 3B-4, 3B-5, and 3B-6.) Also, signs may be used in lieu of pavement markings on low-volume roads for longer periods, when this practice is in keeping with the State's or highway agency's policy. These signs should be placed in accordance with sections 2E-1, 2B-22, and 2C-38.

(3) The interim use of edgelines, channelizing lines, lane reduction transitions, gore markings and other longitudinal markings, and the various non-longitudinal markings (stop line, railroad crossings, crosswalks, words, symbols, etc.) should be in keeping with the state's or highway agency's policy.

c. Raised Pavement Markers

Raised/recessed pavement markers should be considered for use along surfaced detour or temporary roadway and other changed or new travel lane alignments, because of the need to accentuate changed travel paths and their wet-weather performance capabilities.

Retroreflective raised/recessed pavement markers, or non-retroreflective raised/recessed pavement markers supplemented by retroreflective markers, may be substituted for, or used as a supplement to markings prescribed in sections 3A and 3B and subsection b, above.

d. Delineators

Delineators may be used in work areas to indicate the alignment of the roadway and to outline the required vehicle path through the temporary traffic control zone. Delineators, when used, shall be used in combination with, or be supplemental to, other traffic control devices.

When used, delineators shall be mounted on suitable supports so that the reflecting unit is about 4 feet above the near roadway edge. The standard color for delineators used along both sides of two-way streets and highways and the right side of one-way roadways shall be white. Delineators used along the left side of one-way roadways shall be yellow. Spacing along roadway curves should be as set forth in section 3D-5, and should be spaced so that several delineators are always visible to the driver.

6F-7. LIGHTING DEVICES

a. Function

Temporary traffic control activities often create conditions on or near the traveled way that are particularly unexpected at night, when drivers' visibility is sharply reduced. It is often desirable and necessary to supplement retroreflectorized signs, barriers, and channelizing devices with lighting devices.

Four types of lighting devices are commonly used: floodlights, hazard identification beacons, steady-burn electric lamps, and warning lights.

In work areas where a study indicates a nighttime accident problem can be corrected with area illumination, consideration may be given to providing roadway lighting.

b. Floodlights

On temporary traffic control projects, floodlights have a limited but important application. Temporary traffic control activities on urban freeways must frequently be conducted during nighttime periods when traffic volumes are lower. Sometimes, large temporary traffic control contracts are also operated on double shifts requiring night work. When nighttime work is required for these or similar types of projects, floodlights are used to illuminate flagger stations, equipment crossings, and other areas where existing light is not adequate for the work to be performed safely.

In no case shall floodlighting be permitted to create a disabling glare for drivers. The adequacy of the floodlight placement and elimination of potential glare can best be determined by driving through and observing the floodlighted area from each direction on the main roadway after initial floodlight setup.

Maintenance activities on urban freeways with high-volume, high-density traffic conditions are frequently conducted during nighttime periods (with low traffic volumes). Good floodlighting of the work site is necessary because the workers need to see what they are doing, and because the workers and the work space be protected from, and seen by, passing drivers.

c. Flashing Identification Beacons (Flashing Electric Lights)

A flashing identification beacon is a flashing yellow light (minimum diameter, 8 inches) used at points of special concern to alert drivers' attention to these conditions. [Editor's Note: this is an accurate replication of the original sentence.] When used, the flashing beacon should operate 24 hours a day.

On temporary traffic control projects, because of the time and effort required to install these units and put them into operation, they are generally used at locations where frequent changes would not be required.

On projects where an existing dual highway is being upgraded to freeway standards (which requires the use of crossovers to permit stage construction), flashing beacons have been used effectively to call drivers' attention to the condition created by the channelizing devices. Similarly, the temporary terminus of a freeway (where traffic is channelized into an exit) is a location where beacons have alerted drivers of the speed reduction necessary in transitioning from freeway to local road operations.

Flashing identification beacons may be used singly or in groups containing more than one unit.

During normal daytime maintenance operations, the functions of flashing beacons are adequately provided by rotating dome or strobe lights on maintenance vehicles. However, flashing beacons may be installed at locations

where maintenance activity requires an obstruction to remain in the roadway at night. (See section 4E-5.)

d. Steady-Burning Electric Lamps

As used herein, steady-burning electric lamps shall mean a series of low-wattage yellow electric lamps. They may be used to mark obstructions, but they are generally less effective than flashing lights for such use, because of their attention-getting effect. However, lights are needed to delineate the traveled way through and around obstructions in a temporary traffic control zone, the delineation shall be accomplished by steady-burning

Steady-burning lamps, placed in a line on appropriate channelizing devices, are effective in delineating the proper vehicle path through temporary traffic control zones that require changing patterns of traffic movement. Steady-burning lamps are also used on detours, on lane closures, when the roadway alignment changes in and other situations where the headlights do not provide retroreflection to delineate the intended vehicle

The application of these devices during maintenance work is infrequent due to the generally short-term nature of the work. A type of maintenance activity where steady-burning lamps could be used is removal and replacement of a part of a bridge deck. The lamps could be mounted on barricades and help channel traffic around the work space.

e. Warning Lights

The light weight and portability of warning lights are advantages that make these devices useful as supplements to the retroreflectorization on hazard warning devices. The flashing lights are effective in attracting a driver's attention and, therefore, provide an excellent means of identifying the hazard.

As used herein, warning lights are portable, lens-directed, enclosed lights. The color of the light emitted shall be yellow. They may be used in either a steady-burn or flashing mode. Warning lights shall be in accordance with the current ITE Purchase Specification for Flashing and Steady-Burn Warning Lights¹².

¹² Included in the Equipment and Material Standards of the Institute of Transportation Engineers Publication ST 017; 525 School Street, S.W., Suite 410, Washington, D.C. 20024. Telephone: 202-554-8050.

Warning lights shall have a minimum mounting height of 30 inches to the bottom of the lens. Type A low intensity flashing warning lights are most commonly mounted on barricades, drums, vertical panels, or on warning signs, and are intended to warn drivers that they are approaching or in a hazardous area.

Type B high-intensity flashing warning lights are normally mounted on advance warning signs or on independent supports. Extremely hazardous site conditions within temporary traffic control zones may require that the lights be effective in daylight as well as dark. They are designed to operate 24 hours per day. Flashing lights shall not be used for delineation, as they would tend to obscure the desired vehicle path.

Type C steady-burn lights are intended to be used to delineate the edge of the traveled way on detour curves, lane changes, on lane closures, and on other similar conditions.

Type A low intensity flashing warning lights and Type C steady-burn warning lights shall be maintained so that they be visible on a clear night from a distance of 3,000 feet. Type B high intensity flashing warning lights shall

maintained so as to be visible on a sunny day, when viewed without the sun directly on or behind the device from a distance of 1,000 feet.

6F-8. OTHER DEVICES

a. Impact Attenuators

Impact attenuators are systems that mitigate the effects of errant vehicles that strike hazards, either by slowing or decelerating the vehicle to a stop when hit head-on, or by redirecting the errant vehicle. Impact attenuators in temporary traffic control zones protect the motorists from the exposed ends of barriers, fixed objects, and other hazards. Two types of impact attenuators used in temporary traffic control zones are roadside attenuators and truck-mounted attenuators (TMA's). Specific information on the use of impact attenuators can be found in the AASHTO Roadside Design Guide, Chapter 9.¹³

¹³ AASHTO 444 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

Attenuators must pass acceptable performance testing and be designed for each application to ensure performance that will safely stop or redirect errant vehicles. Periodic inspection of these devices is necessary to assure that attenuators function as intended throughout their useful life or that they undergo prompt repair/replacement if hit or damaged.

(1) Roadside Attenuators

Roadside attenuators are used in the same manner as permanent highway installations to protect motorists from the exposed ends of barriers, fixed objects, and other hazards. Two types of stationary attenuators are commonly used and must be designed for the specific application intended as follows:

(a) Redirective Type

The redirective type is an assembled unit designed to absorb head-on vehicle impacts and telescope toward the rear. It also may be capable of absorbing side impacts by redirecting a vehicle.

Redirective attenuators normally are used when the exposed object is narrow, or when space for a nonredirective attenuator is unavailable, such as on surface streets near adjacent intersecting roadways. The attenuator width must be wider than the hazard object, but as close to the object width as possible, to prevent its lateral intrusion into the traffic lanes.

(b) Nonredirective Type

The nonredirective type may be struck head-on, and may be the sand-filled plastic barrel system or other accepted energy-absorbing device designed to stop errant vehicles safely.

Nonredirective impact attenuators must be checked frequently for vehicle impacts because, once hit, they may not function as designed for a second hit. When sand-filled barrels are fractured, the sand is scattered, site cleanup is needed, and the attenuator must be restored with replacement barrels and sand.

(2) Truck-Mounted Attenuators

Trucks or trailers are often used as protective vehicles to protect workers or work equipment from errant vehicles. These protective vehicles are normally equipped with flashing arrows, changeable message signs, and/or flashers. They must be located properly in advance of the workers and/or equipment they are protecting. However, these protective vehicles may themselves cause injuries to occupants of the errant vehicles if they are not equipped with truck-mounted attenuators.

attenuators (TMA's).

TMA's capable of absorbing the impact of errant vehicles can be attached to the rear of these protective vehicles to reduce the severity of rear-end crashes. There are a variety of TMA designs available.

The protective truck must be positioned a sufficient distance in front of the workers or equipment being protected to allow for appropriate vehicle roll-ahead, but not so far that errant vehicles will travel around the vehicle and strike workers/equipment. The attenuator should be in the full down-and-locked position. For stationary operations, the parking brake should be set and, when possible, the front wheels turned away from the work site.

b. Portable Barriers

Portable barriers are designed to prevent vehicles from penetrating work areas behind the barrier while minimizing occupational injuries. They may also be used to separate two-way traffic. These devices may be constructed of concrete, metal, or any material that can physically prevent vehicular penetration.

Portable barriers may serve to channelize traffic. Use for a specific project should be determined by engineering analysis. However, the protective requirements of the work area, not the channelizing needs, govern the use of portable barriers. When serving the additional function of channelizing traffic, portable barriers should be painted a light color for increased visibility. For nighttime visibility, barriers shall be supplemented with standard reflective delineation, markings, or channelizing devices. More specific information on the use of portable barriers and impact attenuators can be obtained from chapters 8 and 9 respectively, of the AASHTO Roadside Design Guide.¹⁴

¹⁴ AASHTO, 444 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

Warning lights may be mounted on continuous barriers. On each side of the roadway only the first two warning lights at the start of a continuous barrier should be Type B flashing. Subsequent warning lights on the barrier shall be Type C yellow, steady-burning for channelization.

The effect of striking the ends of barriers should be mitigated by use of impact attenuators or by flaring the ends of barriers away from the traveled way.

c. Temporary Traffic Signals

Temporary traffic signals can be used for special application to control traffic flow at temporary traffic control zones. These applications include a highway intersection with a temporary haul road or equipment crossing a temporary traffic control zone with alternate one-way traffic flow, such as bridge construction.

All traffic signal and control equipment shall meet the standards and specifications prescribed in part IV of the manual.

One-way traffic flow requires an all-red interval of sufficient duration for traffic to clear the portion of the temporary traffic control zone controlled by the traffic signals. To avoid the display of conflicting signals at each end of the temporary traffic control zone, traffic signals shall be either hard-wired or controlled by a central controller.

d. Rumble Strips

Rumble strips are transverse strips of rough-textured surface used to supplement standard or conventional traffic control devices. Rumble strips may be used to alert drivers of unusual or unexpected traffic conditions or road geometrics, or to bring the driver's attention to other warning devices. They provide a vibratory and auditory warning that supplements visual stimuli.

A rumble strip may consist of raised strips or depressed grooves. The cross-section may be rectangular, circular, or trapezoidal in shape. The strips or grooves should be placed transverse to the direction of traffic. The spacing intervals between rumble strip pads should be reduced as the distance to the hazard diminishes, to create a sensation of acceleration for motorists.

The first rumble strip pad should be placed before the advance warning devices. The last rumble strip pad should be placed a minimum of 250 feet in advance of the traffic condition, gore, work space, or stop point. Rumble strip pads should not be placed on short horizontal or vertical curves where loss of vehicle control may occur because of the action of the rumble strips on a vehicle's suspension system. Rumble strips may be used in conjunction with other traffic control devices.

A sign warning drivers of the presence of rumble strips may be placed in advance of the strips.

e. Screens

Screening is used to block the driver's view of activities that can distract from the driving task. Screening contains the work area and keeps dust and debris off the pavement. Screens are primarily useful on long-term temporary traffic control projects.

Screens may improve safety and traffic flow where traffic volumes approach the roadway capacity because they discourage "gawking" and reduce headlight glare from oncoming traffic.

Screens may be mounted on the top of portable concrete barriers that separate two-way traffic. Screens should not be mounted where they could restrict driver visibility and sight distance. Additional information regarding screens can be obtained from chapter 9 of the AASHTO Roadside Design Guide.¹⁵

¹⁵ AASHTO, 444 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

Opposing Traffic Lane Divider

Opposing traffic lane dividers are delineation devices used center lane dividers to separate opposing traffic on a two-lane, two-way operation. The upright, orange-colored panel shall be approximately 12 inches wide by 18 inches high. The legend on the divider shall be two opposing arrows, similar to those in the legend on the TWO-WAY TRAFFIC sign (W6-3). The divider should be made of lightweight material.