

**MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES
FOR STREETS AND HIGHWAYS**

**SUGGESTED CHANGES AND ADDITIONS
PERTAINING TO LIGHT RAIL GRADE CROSSINGS**

FINAL DRAFT

**Prepared by:
KORVE ENGINEERING RESEARCH TEAM**

March 1995

**SUGGESTED REVISIONS TO THE
MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES
PERTAINING TO LIGHT RAIL GRADE CROSSINGS**

Introduction

This document contains suggested additions and revisions to the *Manual on Uniform Traffic Control Devices* (MUTCD) pertaining to light rail transit (LRT):

- 1) A new Part X contains information for LRT operations. This new Part was developed by Korve Engineering, Inc. while under contract to the Transportation Research Board, Transit Cooperative Research Program (TCRP). The title of TCRP Project A-5 is *Integration of Light Rail Transit into City Streets*. The TCRP was formed under the Intermodal Surface Transportation Efficiency Act (ISTEA) by memorandum agreement between the Federal Transit Association, the Transportation Research Board, and the Transit Development Corporation (the education and training branch of the American Public Transit Association).

- 2) Several suggested revisions to Sections A through D are set forth that complement the new Part X. These revisions include (a) a broadened context for the chapter and (b) further examples of crossing gate designs that relate to LRT operations.

The proposed Part X is designed as an addition to the existing Manual. Therefore, prefatory materials have been omitted, and duplication has been kept to a minimum.

Throughout Part X, reference is made to a proposed LRT alignment classification system. This classification system has been developed based on detailed interviews and field visits to the ten North American LRT systems. All the trackage in these systems can be categorized as one of the nine alignment types.

Areas requiring further study are identified throughout Part X.

Meanings of "Shall," "Should," and "May"

In this Part as in other parts of the Manual, the words "shall," "should," and "may" are used to describe specific conditions concerning traffic control devices. To clarify the meanings intended by use of these words, the following definitions are provided:

- SHALL - A mandatory condition. Where certain requirements in the design or application of the device are described with the "shall" stipulation, it is mandatory that these requirements be met.
- SHOULD - An advisory condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.
- MAY - A permissive condition. No requirement for design or application is intended. If a particular device is used under the "may" condition, however, its design shall follow the prescribed format.

**MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES
FOR STREETS AND HIGHWAYS**

**Part VIII
TRAFFIC CONTROL SYSTEMS FOR
RAILROAD-HIGHWAY GRADE CROSSINGS**

**SUGGESTED CHANGES TO
SECTIONS A THROUGH D**

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Changes are proposed in the following sections to (a) broaden the context of the chapter and (b) give further examples of crossing gate designs that relate to LRV operations.

PAGE	SECTION	CHANGE
8A-1	8A-1	Insert paragraph after second paragraph to describe expanded scope of chapter.
8C-1	8C-2	Modify text of first paragraph to include "other audible devices."
8C-3	8C-4	Add the phrase in bold to the second sentence "gate arm with at least three red lights. "
8C-4	8C-4	Insert paragraph describing new Figures 8-8 and 8-9.

Insert to Section 8A-1, Page 8A-1

Sections 8A through 8D apply to all types of railroad-highway grade crossings. Part X applies to light rail-highway grade crossings in semi-exclusive and non-exclusive alignments.

Insert to Section 8C-4, Page 8C-4

Where automatic gates are to be installed adjacent to a sidewalk and where right-of-way conditions permit, automatic gates should be located on the inside edge of the sidewalk, so that the gate arm will extend across the sidewalk (Figure 8-8), provided this does not make the gate arm longer than 38 feet. At those crossings requiring the gate arm to be longer than 38 feet, a second automatic gate should be placed in the roadway median.

Raised medians or center line curbs should be constructed on the approaches to the crossing to discourage motorists from driving around lowered crossing gates. Skirts or an expanded target area may be added to the bottom of the gate arm, where visibility is a problem. Figure 8-9 shows a railroad gate positioned on the curbside of the sidewalk, a typical placement for a gate used in conjunction with an optional pedestrian gate arm.

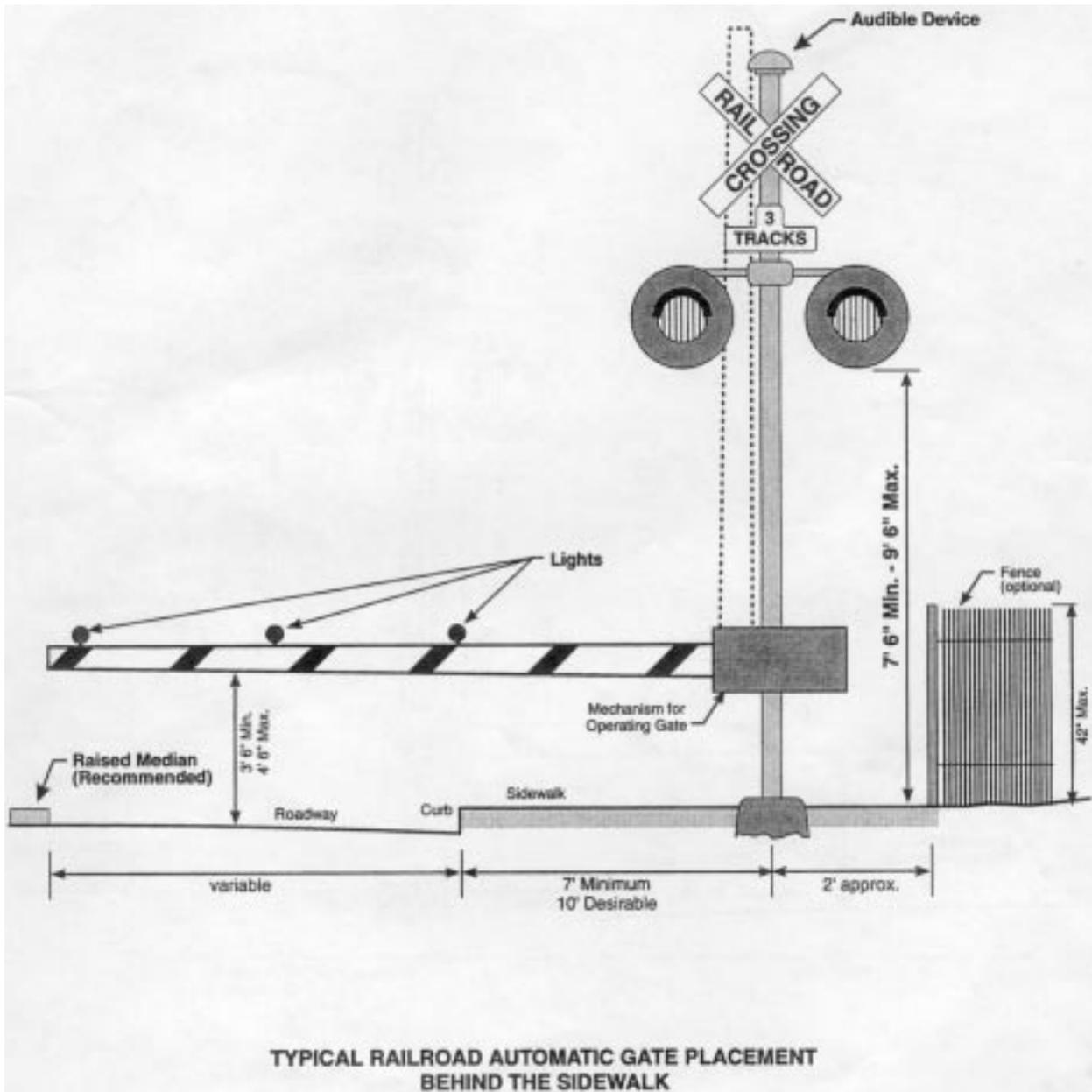
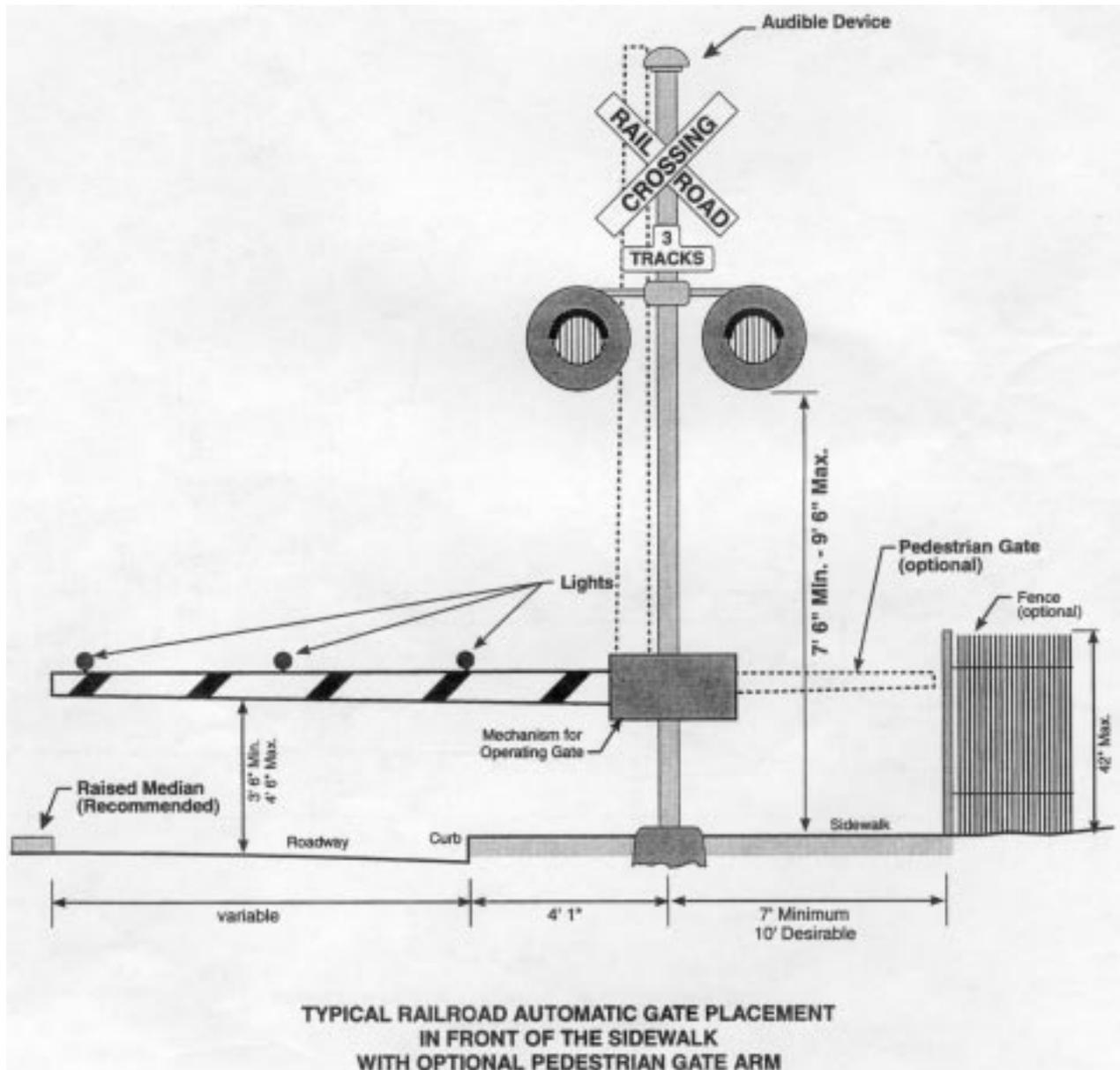


Figure 8-8
TYPICAL RAILROAD AUTOMATIC GATE PLACEMENT



**Figure 8-9
TYPICAL RAILROAD AUTOMATIC GATE PLACEMENT**

**MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES
FOR STREETS AND HIGHWAYS**

**Part X
TRAFFIC CONTROL SYSTEMS FOR
LIGHT RAIL-HIGHWAY GRADE CROSSINGS**

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March 1995

TABLE OF CONTENTS

10-1	INTRODUCTION.....	10-1
	10-1.1 Purpose and Scope.....	10-1
	10-1.2 Types of Light Rail Transit Alignments	10-2
	10-1.3 Engineering Study Required	10-6
10-2	SIGNS AND MARKINGS.....	10-7
	10-2.1 Regulatory Signs.....	10-7
	10-2.2 Warning Signs.....	10-24
	10-2.3 Guide Signs	10-34
	10-2.4 Pavement Markings - Motor Vehicles	10-34
	10-2.5 Pavement Markings - Pedestrians.....	10-42
	10-2.6 Illumination at LRT Crossings	10-43
10-3	GRADE CROSSING CONTROL SYSTEMS.....	10-44
	10-3.1 Purpose and Meaning	10-44
	10-3.2 Automatic Gates	10-45
	10-3.3 Flashing Light Signals	10-46
	10-3.4 Traffic Signals	10-47
	10-3.5 Light Rail Transit Signal Indications	10-49
	10-3.6 Pedestrian Crossing Control Systems.....	10-53

LIST OF FIGURES

Figure 10-1
 NO TURNS INTERNALLY ILLUMINATED SIGNS 10-12

Figure 10-2
 NO TURNS ACROSS LRT TRACKS SIGNS 10-14

Figure 10-3
 PREFERENTIAL LRT RIGHT-OF-WAY SIGNING 10-16

Figure 10-4
 DO NOT PASS STOPPED LRV SIGN 10-17

Figure 10-5
 NO VEHICLES ON TRACKS SIGN..... 10-19

Figure 10-6
 DIVIDED HIGHWAY WITH MEDIAN RUNNING LRT CROSSING SIGNS 10-20

Figure 10-7
 STOP LINE SIGNS 10-22

Figure 10-8
 PEDESTRIAN AND BICYCLE RAILROAD GRADE CROSSING SIGNS 10-25

Figure 10-9
 LIGHT RAIL TRANSIT CROSSING SIGNS..... 10-27

Figure 10-10
 FLASHING INTERNALLY ILLUMINATED TRAIN
 APPROACHING WARNING SIGNS..... 10-30

Figure 10-11
 SECOND TRAIN INTERNALLY ILLUMINATED SIGNS 10-33

Figure 10-12
 LIGHT RAIL STATION SIGN 10-35

Figure 10-13
 TYPICAL DYNAMIC ENVELOPE DELINEATION 10-37

Figure 10-14
 POSSIBLE APPLICATIONS OF LOW PROFILE PAVEMENT BARS..... 10-41

LIST OF FIGURES

Figure 10-15	
LRT SIGNAL ASPECTS.....	10-52
Figure 10-16	
SEPARATE SIGNAL INDICATIONS FOR DIVERSION SWITCH POSITIONS	10-54
Figure 10-17	
PEDESTRIAN CROSSING WARNING DEVICES - FLASHING LIGHT SIGNAL ASSEMBLY.....	10-57
Figure 10-18	
SINGLE UNIT PEDESTRIAN AUTOMATIC GATES	10-60
Figure 10-19	
RECOMMENDED PLACEMENT OF PEDESTRIAN AUTOMATIC GATES.....	10-61
Figure 10-20	
SWING GATES.....	10-63
Figure 10-21	
BEDSTEAD BARRIERS AT LRT CROSSING.....	10-65
Figure 10-22	
Z-CROSSING CHANNELIZATION.....	10-67

LIST OF TABLES

Table 10-1 Maximum Permitted Speeds for LRT Systems by Alignment Type.. 10-6

Table 10-2 Use of Active Internally Illuminated REGULATORY Signs
for Parallel Traffic Turning Across LRT Tracks 10-11

Table 10-3 Use of Active Internally Illuminated WARNING Signs
for Parallel Traffic Turning Across LRT Tracks 10-31

Part X. TRAFFIC CONTROL SYSTEMS FOR LIGHT RAIL-HIGHWAY GRADE CROSSINGS

10-1 Introduction

10-1.1 Purpose and Scope

This section provides guidelines for light rail transit. It brings together for easy reference the basic signs, signals, symbols, markings, and related information that affect the operation of LRT systems in semi-exclusive and non-exclusive alignments. Where light rail and railroad share a common right-of-way, the traffic control devices for railroad systems and practices shall govern. Signing, striping, or signals specific to LRT may be introduced into the existing control system if deemed necessary or appropriate by a pedestrian or traffic engineering study.

The purpose of this section is to provide information to facilitate the safe, orderly and integrated movement of all traffic, including light rail, throughout the public highway system, and to provide such guidance and warnings as may be needed for the safe and informed operation of individual elements of the transportation network. It is intended to assist those involved in the planning, design, and operation of light rail systems by providing a consistent set of guidelines and standards for LRT operations at low to moderate speeds.

Achieving uniformity and consistent use of traffic control devices is an important underlying objective. LRT operators in many cities are currently faced with different sign

types and signal indications in the same system. Motorists are often confronted with varying sign types and signal indications in different cities. This leads to confusion, congestion, and accidents. Uniformity simplifies the task of the road user, the pedestrian, and the LRT operator because it improves recognition and understanding. It aids the user by providing standard interpretations for signs and signals. This results in better observance of traffic controls and improved safety. Uniformity of traffic control devices is beneficial through economy in manufacture, installation, maintenance and administration. The use of uniform traffic control devices does not, in itself, constitute uniformity; uniformity also requires consistency in application. A standard device used where it is not appropriate is as objectionable as a nonstandard device; in fact, it may be worse in that such misuse may result in disrespect at locations where the device is needed.

10-1.2 Types of Light Rail Transit Alignments

Light Rail Transit (LRT) is a mode of urban transportation that employs light rail vehicles (LRV) or traditional streetcars capable of operating on surface streets in mixed traffic, on surface streets in separate rights-of-way, or in exclusive rights-of-way. Grade crossings of highways and light rail transit can occur at intersections or at mid-block locations. Light rail alignments can be grouped into one of the following nine alignment types.

- a. Exclusive: An LRT right-of-way without at-grade crossings that is gradeseparated or protected by a fence or substantial barrier, as appropriate to the location (includes subways and aerial

structures). Motor vehicles, pedestrians, and bicycles are prohibited within the right-of-way.

- b. Semi-Exclusive: An LRT alignment that is in a separate right-of-way or in street right-of-way where motor vehicles and/or pedestrians cross at designated crossings only. These alignments are

Type b.1: An LRT right-of-way with at-grade automobile, bicycle and/or pedestrian crossings, protected between crossings by fencing or substantial barriers, if appropriate to the location. Motor vehicles, bicycles and/or pedestrians cross the right-of-way at designated crossings only.

Type b.2: An LRT alignment within street right-of-way, but protected by 6-inch or higher curbs and fences between crossings. The fences are located outside the tracks. Motor vehicles, bicycles and pedestrians cross the right-of-way at designated crossings only.

Type b.3: An LRT alignment within street right-of-way, but protected by 6-inch or higher curbs between crossings. A fence may be located between the tracks. Motor vehicles, bicycles and pedestrians cross the right-of-way at designated crossings only.

Type b.4: An LRT alignment within street right-of-way, but separated by mountable curbs (with a height less than 6 inches), striping, and/or lane designation. Motor vehicles, bicycles and pedestrians cross the right-of-way at designated crossings only.

Type b.5: An LRT alignment within LRT/Pedestrian Mall right-of-way adjacent to a parallel roadway which is physically separated by a 6-inch or higher curb. Pedestrians cross the LRT right-of-way freely but cross the parallel roadway at designated crossings only. Typically the LRT right-of-way is delineated by discernible visual and textural pavement markings and/or striping. Motor vehicles and bicycles cross the LRT/Pedestrian Mall right-of-way at designated crossings only.

c. Non-Exclusive: An LRT corridor where LRVs operate in mixed traffic with automobiles, trucks, buses, bicycles and pedestrians. These corridors are:

Type c.1: *Mixed Traffic Operations/Surface Street.* Motor vehicles and bicycles operate with LRVs on surface streets. Pedestrians cross the right-of-way at designated crossings only.

Type c.2: *Transit Malls.* Transit vehicles may operate with LRVs in a transit exclusive area for transporting, embarking, and

disembarking passengers. A raised curb separates the transit/LRV right-of-way from the pedestrian way. Non-transit motor vehicles and bicycles are prohibited in the right-of-way. Motor vehicles, bicycles and pedestrians cross the right-of-way at designated crossings only. Delivery vehicles may be allowed at certain times.

Type c.3: *LRT/Pedestrian Mall.* LRVs and pedestrians share the right-of-way. Motor vehicles and bicycles are prohibited from operating on or adjacent to the LRT tracks. Pedestrians may cross the LRT right-of-way freely. Typically, the LRT right-of-way is delineated by discernible visual and textural pavement markings and/or striping. Motor vehicles and bicycles cross the right-of-way at designated crossings only. Delivery vehicles may be allowed at certain times.

Table 10-1 shows typical maximum permitted speeds for LRT systems by type of alignment.

Table 10-1 Maximum Permitted Speeds for LRT Systems by Alignment Type¹

ALIGNMENT CLASSIFICATION		LOCATION	TYPICAL MAXIMUM PERMITTED LRV SPEED
a. EXCLUSIVE		All locations	Above 35 mph
b. SEMI-EXCLUSIVE	b.1	Between crossings	Above 35 mph
		At crossings (gated)	Above 35 mph
	b.2	Between crossings	Legal speed of parallel traffic + 10 mph
		At gated crossings	Legal speed of parallel traffic + 10 mph
		At non-gated crossings	Legal speed of parallel traffic, without exceeding 35 mph
	b.3 & b.4	All locations	Legal speed of parallel traffic, without exceeding 35 mph
b.5	All locations	20 mph ²	
c. NON-EXCLUSIVE	c.1	All locations	Legal speed of parallel traffic, without exceeding 35 mph
	c.2 & c.3	All locations	20 mph ²

¹ Sources: California Public Utilities Commission (General Order 143A) and Korve Engineering, Inc.

² Lower speed may be required for pedestrian malls (c.3) paved flush with the tracks.

10-1.3 Engineering Study Required

Traffic control devices relative to LRT operations have evolved over a period of many years. Consequently, many existing devices may not fully conform to the standards of this section. It may not be economically feasible or practical to improve and upgrade non-standard devices to current standards at once. However, existing devices not meeting current standards should be improved and upgraded according to the recommendations herein, either through a program of replacement or when damaged and inoperable.

The decision to use a particular device at a given location should be made on the basis of an engineering study of the location. Thus, while this section provides guidelines and

standards for design and application of traffic control devices, it is not a substitute for engineering judgment. The provisions in this section are guidelines and standards for the installation of uniform traffic control devices, not legal requirements for installation. Legal requirements do exist in certain political jurisdictions and must be investigated.

10-2 Signs and Markings

Signs and markings are provided for the purpose of identifying and directing attention to specific situations/locations so that LRT operators, motorists, bicyclists and pedestrians may take appropriate action. Standardization of design, position, and location, while not always attainable, should be the end result or goal. Signs should be located to optimize visibility and minimize distractions. Excess use of signs should be avoided. Under special conditions such as alleys, parking facilities, pedestrian-only applications, etc., the use of smaller than specified sign dimensions may be used. When sign sizes are changed, standard proportions, shapes, and colors shall be retained.

10-2.1 Regulatory Signs

1. Stop Sign at LRT Grade Crossings (R1-1)

All LRT crossings shall be equipped with stop signs, traffic signals, or gates, depending upon the type of alignment, LRV and traffic operating speeds, sight distances, and cross street traffic volumes. No LRT grade crossing should be without a regulatory traffic control device. A STOP sign should be the minimum traffic control device.

The use of STOP signs at LRT-highway grade crossings shall be limited to those crossings selected after need is established by a detailed traffic engineering study. Such crossings should have the following characteristics:

- Highway should be secondary in character with low traffic counts (e.g., minor cross street with one lane each way, alley, driveway).
- Line of sight for the operator of an approaching LRV is adequate, allowing sufficient distance to both sound the horn and then bring the LRV to a safe stop.
- At the stop line the motorist has sufficient sight distance down the track(s) to afford ample time for the vehicle to cross the track(s) before the arrival of the LRV(s).
- The signs should generally be located in areas of non-exclusive alignments (type c).
- The LRT is in a median running configuration so that motor vehicles on the cross street do not stop on the LRT alignment while waiting to merge into the parallel street traffic stream, as would happen when the LRT is in a side running configuration.

Generally, stop signs should be used in semi-exclusive, non-gated alignments (type b.2, b.3, b.4, b.5) only when:

- The minor, intersecting roadway has average daily traffic volumes of less than 1500 vehicles per day.
- Motor vehicle speeds on the major street (parallel to the LRT tracks) do not exceed 25 mph.

- LRV operating speeds do not exceed 25 mph.
- Stopping sight distance is adequate for both motorists and LRV operators.
- LRT tracks are located such that motor vehicles will not stop on the track(s) waiting to enter the parallel street traffic stream. Generally, motor vehicles are likely to stop on the LRT track(s) while waiting to enter the major street when LRT is running on the side adjacent to the minor street.
- The intersection does not meet the traffic signal warrants set forth in Section 4C of this Manual.

When a STOP sign is installed at a grade crossing, it should be erected on a separate post at the point where the vehicle is to STOP, or as near thereto as possible. A STOP sign shall not be installed downstream from the LRT crossing to prevent vehicle queue spillback into the LRV's dynamic envelope.

2. Turn Restrictions Signs (R3-1, 1a, 2, 2a)

At signalized intersections, left and right turns by parallel traffic in front of an LRV present potential conflicts, which may require one or more of the following actions:

- Prohibiting left/right turns in roadway alignments where LRVs and vehicular traffic travel parallel along the same highway.
- Controlling left/right turns at signalized intersections where turn movements and LRVs have separate and distinct phases.
- Restricting left/right turns at certain intersections at all times or for specified periods of time.

- Providing an active internally illuminated flashing sign that will alert the turning motorist of an approaching LRV.
- Providing improved visibility for conflicting LRV movements.

Active, internally illuminated signs shall be used in accordance with the guidelines shown in Table 10-2 to restrict parallel left or right turns at intersections or driveways that are crossed by LRT. Active internally illuminated regulatory signs should be used on semi-exclusive (type b) gated alignments at intersections (or driveways) that are controlled by stop signs or traffic signals without an arrow indication. They shall be used on semi-exclusive (type b) non-gated alignments at intersections (or driveways) that are controlled by stop signs or traffic signals without an arrow indication. They shall also be used in double track situations where one track is on a semi-exclusive alignment and the other track is on a non-exclusive alignment. Active internally illuminated regulatory signs are not recommended for mixed traffic (type c) alignments.

At signalized intersections without turn arrow indications, an all-red phase for motor vehicles and pedestrians may be used in combination with the NO TURN ON RED (R10-11a) signs as an alternate to using active, internally illuminated regulatory signs (R3-1, 2).

Table 10-2 Use of Active Internally Illuminated REGULATORY Signs for Parallel Traffic Turning Across LRV Tracks¹

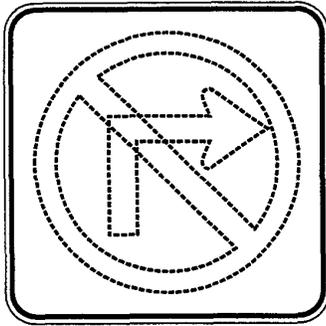
ALIGNMENT TYPE	INTERSECTION TRAFFIC CONTROL DEVICE	ACTIVE "NO LEFT TURN" SIGN (median and side-running locations)	ACTIVE "NO RIGHT TURN" SIGN (side-running locations only)
Semi-Exclusive Gated (type b.2)	Stop ²	Should	Should
	Traffic Signal w/o Arrow ³	Should	Should
	Traffic Signal w/Arrow ⁴	Not recommended	Not recommended
Semi-Exclusive, Non-gated (type b.2, b.3, b.4, b.5)	Stop ²	Shall	Shall
	Traffic Signal w/o Arrow ³	Shall	Shall
	Traffic Signal w/Arrow ⁴	Not recommended	Not recommended

- 1 Alternatively, an all-red phase for motor vehicles and pedestrians may be used in combination with NO TURN ON RED (R10-11a) signs.
- 2 "Stop" refers to a stop-sign controlled intersection or driveway.
- 3 "Without Arrow" refers to a signalized intersection where the turning traffic has no red arrow displayed when an LRV is approaching, but has either a steady green, a red ball, or a flashing red ball displayed.
- 4 "Arrow" refers to a signalized intersection at which the turning traffic has a red arrow displayed when an LRV is approaching. When a turn arrow traffic signal indication is used without approach phasing, an exclusive turn lane should be provided.

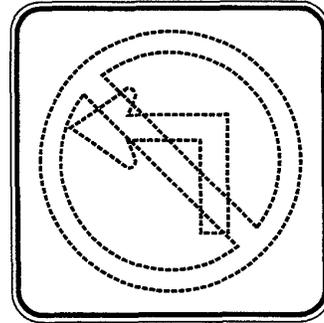
When feasible, a separate left or right-turn lane with a protected turn phase (with turn arrow indications) shall be provided at signalized intersections. The turn arrow indications become the primary traffic control device. In such cases, the active regulatory signs should not be used.

If no separate turn lanes and turn arrow signal indications are provided, active, internally illuminated regulatory signs should be utilized when automatic gates are present and shall be utilized when automatic gates are not present. These signs should display the turn prohibition symbol (R3-1/R3-2) shown in Figure 10-1. However, signs with the legend NO RIGHT/LEFT TURN, also shown in Figure 10-1, may be used. Alternatively, the turn

PREFERRED



R3-1

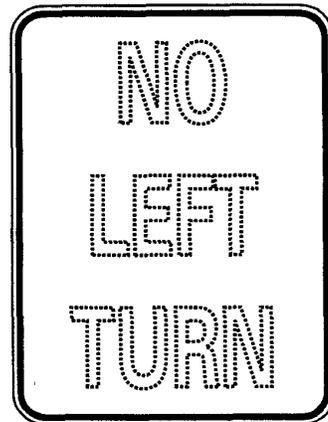
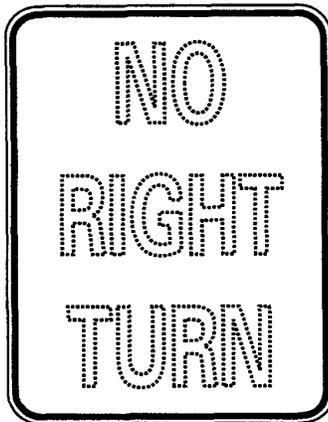


R3-2

24" OR 36" DIAMETER CIRCLE

COLORS
CIRCLE & DIAGONAL - RED (INTERNALLY ILLUMINATED)
ARROW - WHITE (INTERNALLY ILLUMINATED)
BACKGROUND - BLACK (NON-REFLECTIVE)

ALTERNATE



24" x 30"

COLORS
LEGEND - RED (INTERNALLY ILLUMINATED)
BACKGROUND - BLACK (NON-REFLECTIVE)

Figure 10-1
NO TURNS INTERNALLY ILLUMINATED SIGNS

prohibition signs R3-1a or R3-2a may also be used in combination with the WHEN FLASHING supplemental plate and flashing amber beacons as shown in Figure 10-2. Where these signs are required to be installed ("shall" in Table 10-2), a minimum of two active, internally illuminated regulatory signs shall be used to restrict left or right turns at intersections or driveways that are crossed by LRT.

[Further research is needed to determine specifications for placement location and mounting height above the ground. Also, failure modes of these signs need to be addressed.]

Active internally illuminated regulatory signs should follow these guidelines:

- Color: RED and WHITE symbol or RED message, on a BLACK background
- Sequence: STEADY, not flashing. (An alternate operation may include a short flashing period preceding the steady message.) Sign message to be extinguished at all times, except during LRV preemption.
- Message: NO LEFT/RIGHT TURN symbol.
- Construction: Single unit
- Size: 24- or 36-inch diameter (symbolic) or 24 × 30 inches with 6-inch high letters (legend), but may be smaller for low-speed LRV operations (under 20 mph).

As an alternate to installing active, internally illuminated regulatory signs as described above, passive NO LEFT/RIGHT TURN (R3-1, 2) signs may be used to prohibit turning

ALTERNATE



R3-1a
(Proposed)

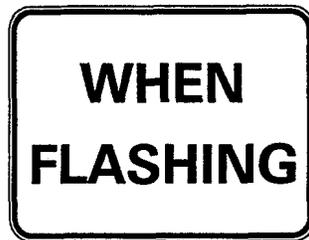


R3-2a
(Proposed)

24" x 24"

COLORS

CIRCLE & DIAGONAL - RED (REFLECTIVE)
ARROW & BORDER & TRACKS - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)



Supplemental Plate

24" x 18"

COLORS

BORDER & LEGEND - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-2
NO TURNS ACROSS LRT TRACKS SIGNS

movements at all times (whether or not an LRV is approaching the crossing). However, alternative routes should exist and be clearly indicated by means of guide signing.

3. Preferential LRT Right-of-Way Signing (R3-18, 19)

Signing for preferential LRT rights-of-way on semi-exclusive alignments should follow the standard regulatory signing principles for preferential lanes described in Section 2B-20 of this Manual. The proposed signs for preferential LRT right-of-ways are shown in Figure 10-3.

Sign R3-18 should be mounted on a post, located adjacent to the LRT right-of-way. As an alternate, sign R3-19 should be mounted overhead, directly above the LRT right-of-way.

[Further research is needed to establish a symbolic lane designation; i.e., arrows to indicate RIGHT, CENTER or LEFT lanes.] Frequency with which these signs are placed is a matter of engineering judgement based on prevailing LRV and motor vehicle speed, block length, distance from intersections, and other considerations necessary to adequately communicate with the driver. Generally, as a minimum, one sign should be installed per city block.

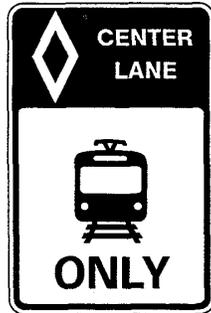
4. Do Not Pass Stopped LRV Sign (R4-1a)

To emphasize that motor vehicles are required to stop behind an LRV that is receiving or discharging passengers in the street in a non-exclusive type c.1 right-of-way where there is no safety zone or island (as per Uniform Vehicle Code, Section 11-1403), a DO NOT PASS STOPPED LRV sign, as shown in Figure 10-4, may be located immediately

PREFERRED



R3-18a
(Proposed)
24" x 30"



R3-18b
(Proposed)
24" x 30"



R3-18c
(Proposed)
24" x 30"

COLORS

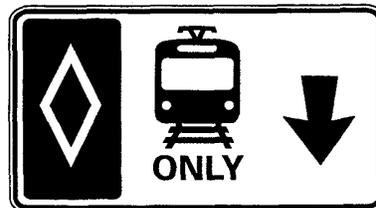
TOP

SYMBOL & LEGEND - WHITE (REFLECTIVE)
BACKGROUND - BLACK (NON-REFLECTIVE)

BOTTOM

SYMBOL & LEGEND - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

ALTERNATE



R3-19
(Proposed)

36" x 24"

COLORS

DIAMOND SYMBOL - WHITE (REFLECTIVE) ON BLACK (NON-REFLECTIVE)
LRV SYMBOL & ARROW - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-3
PREFERENTIAL LRT RIGHT-OF-WAY SIGNING



R4-1a
(Proposed)

24" x 36"

COLORS
SYMBOLS & LEGEND & BORDER - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-4
DO NOT PASS STOPPED LRV SIGN

upstream of an LRV boarding and alighting street stop. If there are multiple lanes, a DO NOT PASS STOPPED LRV sign may be located on a mast arm above the lanes where passing of a stopped LRV that is receiving or discharging passengers could occur.

5. Encroachment Restrictions Sign (R5-1b)

To deter vehicles from encroaching onto the trackway, a NO VEHICLES ON TRACKS sign, shown in Figure 10-5, should be mounted on a 36-inch high flexible post, facing traffic, between a double set of tracks where clearances allow. Alternatively, the R5-1b sign should be mounted on a pole on the curb nearest to where a motor vehicle might encroach onto the LRT trackway or on overhead support wires directly over the LRT alignment. This sign is intended to be used where vehicles tend to drive onto the LRT trackway.

The standard NO VEHICLES ON TRACKS sign shall be 12 × 18 inches. If the sign is mounted on a pole on the curb or on overhead support wires, the sign shall be 24 × 36 inches.

6. Divided Highway with Median Running LRT Crossing Sign (R6-3b, 3c)

The DIVIDED HIGHWAY WITH MEDIAN RUNNING LRT CROSSING sign, shown in Figure 10-6, may be used as a supplemental sign on the approach legs of a roadway that intersects a divided highway where LRVs operate in a wide median-running, semi-exclusive alignment (type b.2, b.3, b.4, b.5). This sign is intended to guide motorists through wide medians, thereby minimizing movements in the wrong direction and/or encroachments of the LRT track area.



R5-1b
(Proposed)

12" x 18"
or
24" x 36"

COLORS
CIRCLE & DIAGONAL - RED (REFLECTIVE)
VEHICLE & BORDER & LEGEND & TRACKS - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-5
NO VEHICLES ON TRACKS SIGN

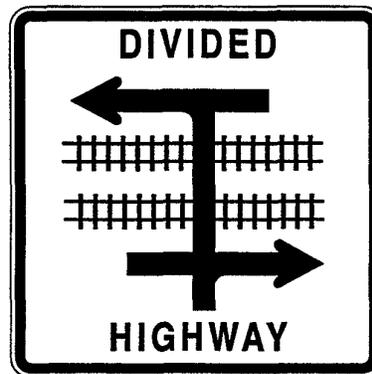


R6-3b
(Proposed)

24" x 24"

COLORS

LEGEND & ARROWS & TRACKS & BORDER - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)



R6-3c
(Proposed)

24" x 24"

COLORS

LEGEND & ARROWS & TRACKS & BORDER - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-6
DIVIDED HIGHWAY WITH MEDIAN RUNNING LRT CROSSING SIGNS

The sign should be mounted separately.

When the DIVIDED HIGHWAY WITH MEDIAN RUNNING LRT CROSSING sign is used at a four-leg intersection, sign R6-3b shall be used. When used at a "T" intersection, sign R6-3c shall be used.

The minimum size sign is 24 × 24 inches.

7. Do Not Stop on Tracks Sign (R8-8)

Whenever an engineering study determines that the potential for vehicles stopping on the tracks is high, a DO NOT STOP ON TRACKS sign (R8-8) should be used (see Section 8B-8). This is often the case if the crossing involves multiple stops for the motor vehicle or there is a possibility of queue spillback onto the LRV's dynamic envelope.

This sign may be located on the right side of the road on the near side of the grade crossing, thus allowing the motorist to observe the sign and comply with its message. On multi-lane roads with medians and one-way roadways, a second sign may be placed on the near left side of the grade crossing to further improve visibility.

8. Stop Here on Red Sign (R10-6a, 6b, 6c, 6d)

The STOP HERE ON RED sign may be needed at certain locations to define the stop line (see Figure 10-7). It should be used to define and facilitate observance of the stop lines (or limit lines) in conjunction with traffic signals and railroad gates. It should be used as



R10-6a
(Existing R10-6)
24" x 36"



R10-6b
(Proposed)
24" x 36"

COLORS
LEGEND & ARROW & BORDER - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)



R10-6c
(Proposed)
30" x 36"



R10-6d
(Proposed)
30" x 36"

COLORS
BORDER & CAUTION LEGEND - RED (REFLECTIVE)
GATE & VEHICLE & STOP LINE LEGEND & ARROW - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-7
STOP LINE SIGNS

a means of emphasizing the dynamic envelope of LRVs. It should be used at locations where vehicles frequently violate the stop line or where it is not obvious to motorists where to stop (i.e., unusual geometries, snow, etc.). The R10-6b sign should be used on one-way streets and two-way streets with median to reinforce the R10-6a sign.

The CAUTION STOP HERE signs (R10-6c and R10-6d) shown in Figure 10-7 may be used as substitutes for the R10-6a or R10-6b signs, respectively, at gated crossing locations.

9. Railroad Crossing (Crossbuck) Sign (R15-1, 2)

The regulatory railroad crossing sign, commonly identified as the "crossbuck" sign, shall utilize a reflective white background with the words RAILROAD CROSSING in black lettering and shall be mounted as shown in Figure 8-1, Section 8B. As an alternative, a reflective white and red crossbuck sign may be used. ***[Further research is needed to determine the effectiveness of this crossbuck type for LRT crossings. The Canadian standard crossbuck is reflective white and red and is drilled for 90-degree mounting.]*** Requirements regarding location and installation of the R15-1 and R15-2 signs are discussed in Section 8B-2.

As a minimum, one crossbuck sign shall be used on each roadway approach to every gated grade crossing, in combination with other traffic control devices. Crossbuck signs should only be used at gated light rail crossings.

10. Pedestrians and/or Bicycles Only Crossing Sign (R15-4)

The regulatory PEDESTRIANS AND/OR BICYCLES ONLY CROSSING signs (R15-4a, R15-4b, R15-4c), shown in Figure 10-8, shall be used to indicate an at-grade rail crossing for pedestrians and/or bicycles only. Sign R15-4a shall be used where it is necessary to keep motor vehicles from using the crossing. Sign R15-4b shall be used where it is necessary to keep motor vehicles and bicycles from using the crossing (i.e., where bicyclists should walk with their bikes). Sign R15-4c shall be used where it is necessary to keep motor vehicles and pedestrians from using the crossing (e.g., an exclusive bicycle trail that crosses LRT tracks).

The standard sign shall be 18 × 30 inches, with black lettering on a white reflective background.

10-2.2 Warning Signs

LRT warning signs are used when it is necessary to warn traffic of the presence of LRVs on or adjacent to a highway or street. The use of LRT warning signs should be kept to a minimum because unnecessary warning of obvious conditions tends to breed disrespect for all signs.

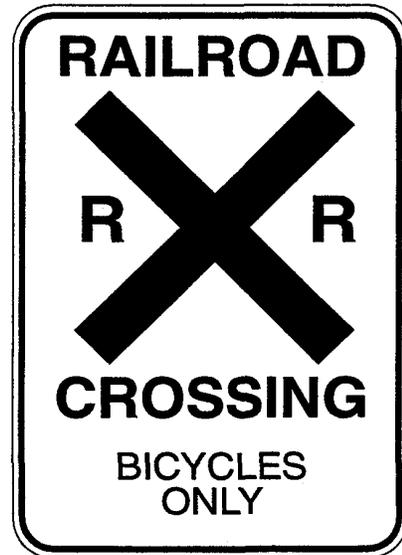
LRV activated flashing amber beacons may be used to supplement advance LRT warning signs. When used, the placement of amber beacons should be coordinated with the placement of other LRV activated signals to avoid overlap and/or confusion.



R15-4a
(Proposed)



R15-4b
(Proposed)



R15-4c
(Proposed)

18" x 30"

COLORS

SYMBOL & LEGEND & BORDER - BLACK (NON-REFLECTIVE)
BACKGROUND - WHITE (REFLECTIVE)

Figure 10-8
PEDESTRIAN AND BICYCLE RAILROAD GRADE CROSSING SIGNS

1. Railroad Advance Warning Signs (W10-1, 2, 3, 4)

A RAILROAD ADVANCE WARNING (W10-1) sign shall be used on each roadway in advance of every gated light rail crossing.

The W10-2, 3, and 4 signs may be installed on highways that are parallel to the light rail alignment. The purpose of these signs is to warn motorists making a turn that a gated or non-gated light rail crossing is ahead.

Placement of the W10-1, 2, 3, and 4 signs shall be in accordance with Section 8B-3.

2. Light Rail Transit Crossing Sign (W10-5, 5a)

A LIGHT RAIL TRANSIT CROSSING (W10-5) sign, shown in Figure 10-9, may be installed in advance of LRT non-gated, signalized crossings of semi-exclusive right-of-way on streets approaching the crossing. This sign should not be installed on streets that are parallel to the tracks. ***[Further research is needed to determine the necessity of this sign in advance of non-gated, traffic signalized LRT crossings (downtown, city-center type situations). While this sign may not provide the motor vehicle driver with any additional, necessary information (i.e., the motor vehicle driver must obey the traffic signal), further consideration needs to be given to the possibility of a traffic signal and/or electrical power failure. In the event of a traffic signal/electrical power failure, this sign would become extremely valuable. Symbol legibility and content may need further study. It may prove desirable to use TRAIN CROSSING or LOOK BOTH WAYS signs.]***

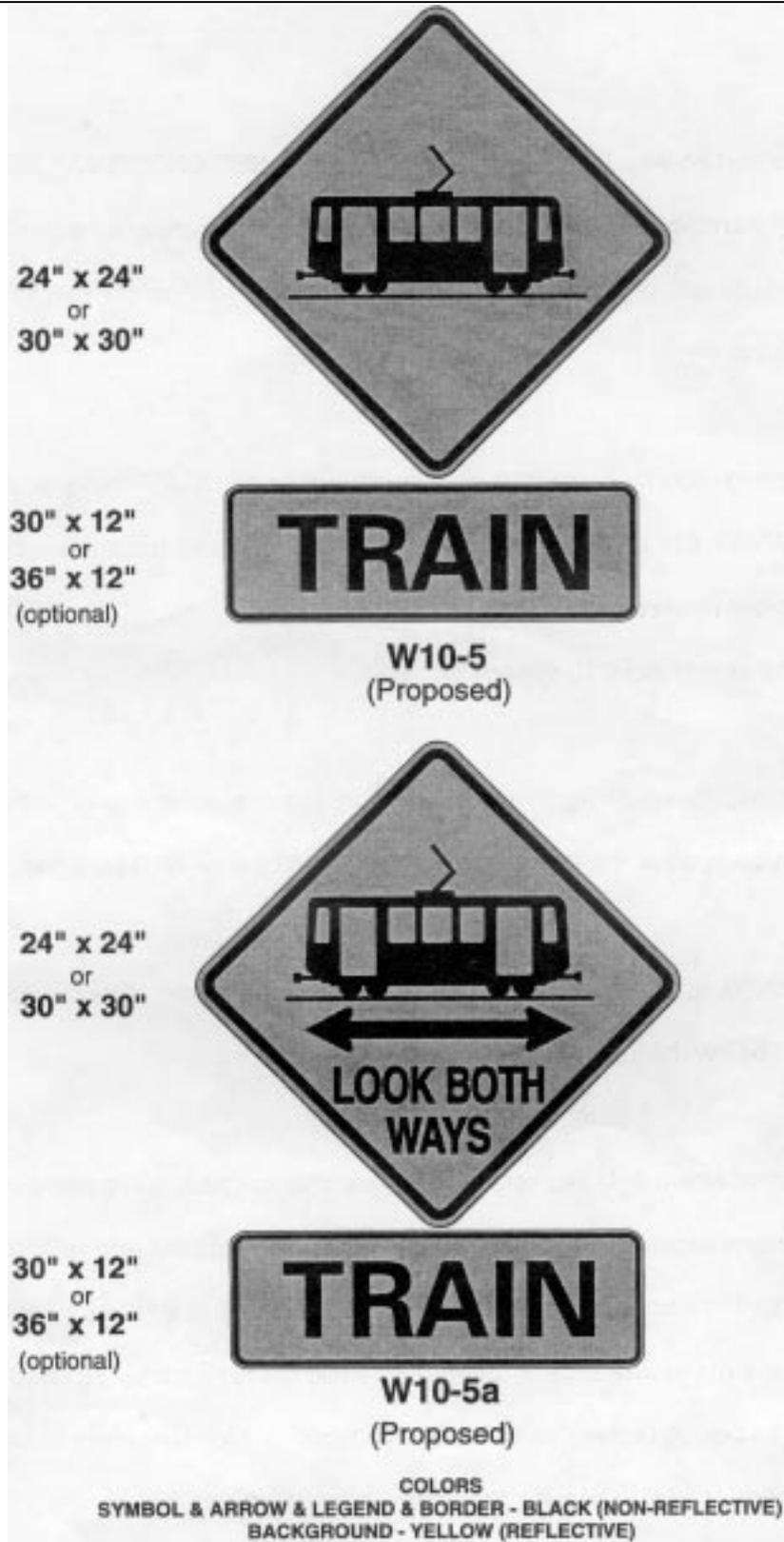


Figure 10-9
LIGHT RAIL TRANSIT CROSSING SIGNS

Where LRVs operate two-way, the advance LIGHT RAILTRANSIT CROSSING/LOOK BOTH WAYS (W10-5a) warning sign (Figure 10-9) shall be used at unsignalized driveways, alleys, and cross streets perpendicular to the track, to alert motorists that LRVs may approach from both ways.

The primary warning sign for signalized pedestrian crossings of LRT tracks shall be the LIGHT RAIL TRANSIT CROSSING (W10-5) sign. At unsignalized pedestrian crossings where LRVs operate two-way, the LIGHT RAIL TRANSIT CROSSING/LOOK BOTH WAYS (W10-5a) warning sign (Figure 10-9) shall be used.

At pedestrian crossings where light rail and railroad share a common right-of-way, the W10-1 sign shall be used at the crossing in lieu of the W10-5 or W10-5a signs.

As per Section 2A-13, an optional sign (educational plaque) displaying the legend TRAIN may be installed below the W10-5 or W10-5a signs.

In those alignments where light rail operates adjacent to railroad, additional pedestrian warning signs and/or signals shall be installed between the light rail and railroad tracks to distinguish between each system's right-of-way. The W10-5 or W10-5a shall be used to warn pedestrians of the presence of LRT tracks, while the W10-1 shall be used to warn them of railroad tracks. A pedestrian safety area should be clearly marked between the light rail and railroad tracks to provide the necessary queuing area.

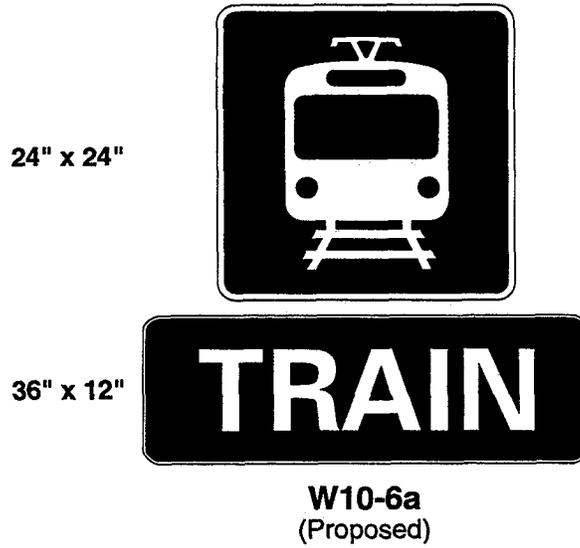
3. Train Approaching Sign (W10-6a, 6b)

A flashing internally illuminated warning sign (W10-6) displaying the front view LRV symbol and the legend TRAIN (W10-6a) or the side view LRV symbol and the legend TRAIN (W10-6b), as shown in Figure 10-10, should be used at street crossings on semi-exclusive, non-gated LRT alignments where left or right-turning parallel traffic is controlled by arrow indications. This advisory sign would alert and warn traffic turning left and/or right across the tracks of a parallel, approaching LRV. Because protected turn phases are provided, the warning sign does not act as the primary control device.

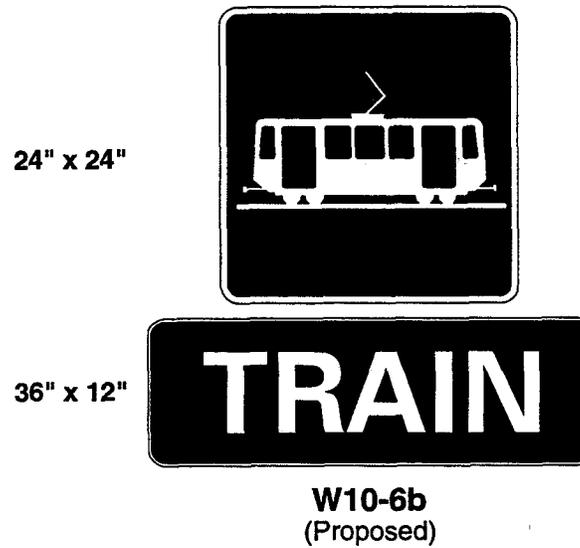
The sign may be used for non-gated alignments at stop-controlled intersections or at signalized intersections without turn arrows. The sign may also be used at intersections along gated alignments. It should not be used for non-exclusive or mixed traffic alignments. ***[Further research is needed to determine specifications for symbol icon, placement location, and mounting height above the ground. Also, redundancy and failure modes of these signs need to be addressed.]***

Table 10-3 summarizes application guidelines for various LRV alignment types and traffic control methods. The warning signs apply to left turns in median-running locations and to both left and right turns in side-running locations.

- Active warning signs may be used at intersections along semi-exclusive, gated alignments (type b.2).
- Active warning signs may be used for semi-exclusive, non-gated alignments (type b.2, b.3, b.4, b.5) at stop sign controlled intersections or at signal controlled intersections without turn arrows.



OR



COLORS
LEGEND - AMBER (INTERNALLY ILLUMINATED)
BACKGROUND - BLACK (NON-REFLECTIVE)

FLASHING INTERNALLY ILLUMINATED TRAIN APPROACHING WARNING SIGNS

Figure 10-10

- Active warning signs should be used at signalized intersections along semi-exclusive, non-gated alignments (types b.2, b.3, b.4, b.5) where the left or right turning parallel traffic is controlled by arrow indications.
- Active warning signs are not recommended along non-exclusive alignments (type c), regardless of the type of regulatory devices used.
- In a double-track situation where one track is in a non-exclusive alignment (type c) and the other track is in a semi-exclusive alignment (type b), the semi-exclusive guidelines shall govern.

Table 10-3 Use of Active Internally Illuminated WARNING Signs for Parallel Traffic Turning Across LRV Tracks¹

ALIGNMENT TYPE	INTERSECTION TRAFFIC CONTROL DEVICE	"TRAIN" APPROACHING SIGN FOR LEFT TURNS (median and side-running locations)	"TRAIN" APPROACHING SIGN FOR RIGHT TURNS (side-running locations only)
Semi-Exclusive Gated (type b.2)	Stop ²	May	May
	Traffic Signal w/o Arrow ³	May	May
	Traffic Signal w/Arrow ⁴	May	May
Semi-Exclusive Non-gated (type b.2, b.3, b.4, b.5)	Stop ²	May	May
	Traffic Signal w/o Arrow ³	May	May
	Traffic Signal w/Arrow ⁴	Should	Should

1 Parallel traffic turning across LRV tracks can turn at standard intersections or at mid-block locations such as driveways.

2 "Stop" refers to a stop-sign controlled intersection or driveway.

3 "Without Arrow" refers to a signalized intersection where the turning traffic has no red arrow displayed when an LRV is approaching, but has either a steady green or red ball or a flashing red ball displayed.

4 "Arrow" refers to a signalized intersection at which the turning traffic has a red arrow displayed when an LRV is approaching. When a turn arrow traffic signal indication is used, an exclusive turn lane is provided.

Active internally illuminated warning signs should follow these guidelines:

- Color: AMBER (YELLOW) message on a BLACK background
- Sequence: FLASHING, not steady. (However, an alternate operation may include a steady message following a short flashing period.) Sign message to be extinguished at all times, except during LRV preemption.
- Message: The LRV symbol shown in Figure 10-10 or the legend TRAIN
- Construction: Single unit
- Size: 24 × 24 inches (symbolic) or 36 × 12 inches (legend) with 8-inch high letters, but may be smaller (i.e., 27 × 9 inches) for low-speed LRV operations (under 20 mph).

4. Second Train Approaching Sign (W10-7)

An LRV activated, flashing, internally illuminated sign with the legend SECOND TRAIN - LOOK LEFT/RIGHT (W10-7) may be used to alert pedestrians that a second (or third, fourth, etc.) LRV is approaching the crossing from a direction that might not be expected (Figure 10-11). This sign should especially be used near LRT stations, track junctions, and/or multiple track alignments (greater than two tracks). The sign should be placed on the far side of the grade crossing and indicate the approaching direction of the second on-coming LRV.

This active internally illuminated warning sign should follow the color and sequence guidelines presented in Section 10-2.2.3.

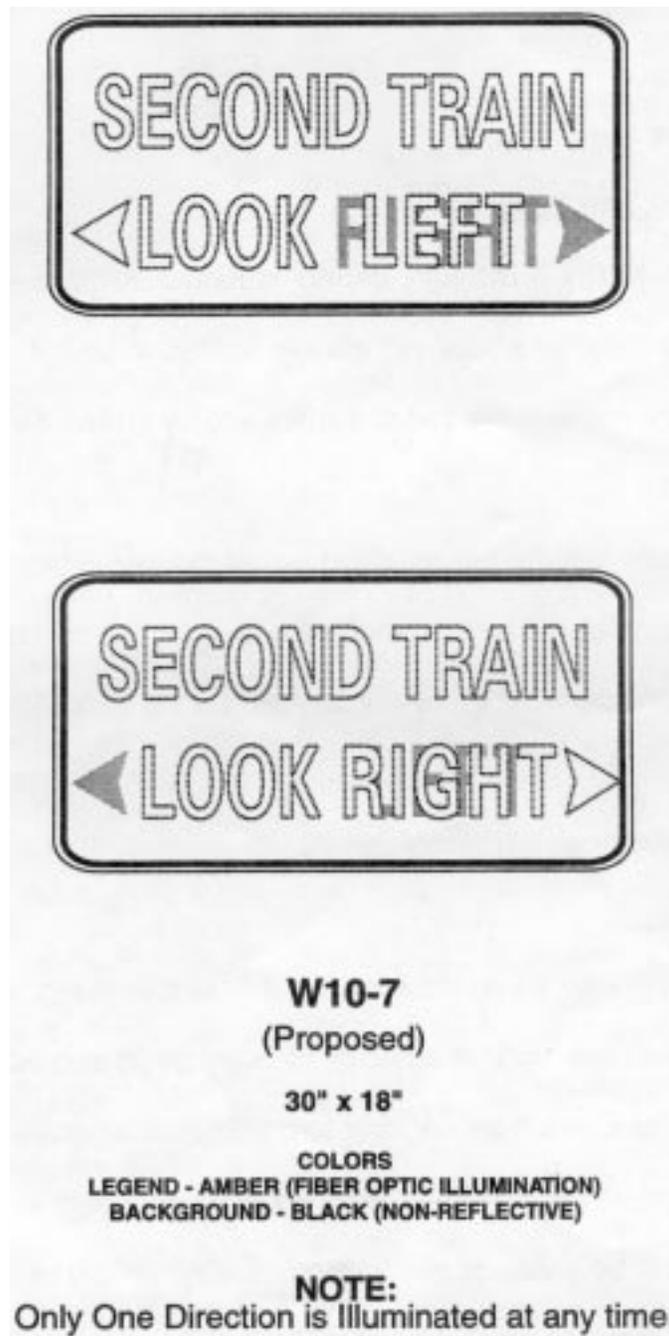


Figure 10-11
SECOND TRAIN INTERNALLY ILLUMINATED SIGNS

[Further research is needed to determine specifications for message, placement location, and mounting height above the ground. Furthermore, additional research is needed to determine its application to unsignalized motor vehicle crossings.]

10-2.3 Guide Signs

1. Light Rail Station Sign (I-7a)

The LIGHT RAIL STATION (I-7a) sign, shown in Figure 10-12, may be used to direct motorists or pedestrians to a light rail station facility or boarding point. It may be supplemented by the name of the transit system and by arrows as necessary.

A supplementary plate may be mounted just below the sign indicating the name of the LRT system, the name of the station and/or the direction to the station. If used on a freeway, the supplementary plate may contain text stating NEXT EXIT.

10-2.4 Pavement Markings - Motor Vehicles

1. Advance Warning

A railroad crossing pavement marking symbol, as illustrated in Figure 8-2 (Section 8B-4), shall be used on each approach in advance of every gated at-grade light rail crossing, excluding parallel exclusive left-turn or right-turn approach lanes. It shall not be used at non-gated crossings. This pavement marking shall be used at mid-block crossing locations (which shall be gated as per Section 10-3.2). If light rail is in a side-running configuration, this pavement marking shall only be used on the perpendicular approach roadway leg where the tracks and gates are located. This pavement marking shall not be used along a parallel roadway if light rail is in a center-running configuration.



I - 7a
(Proposed)
24" x 24"

COLORS
SYMBOL - WHITE (REFLECTIVE)
BACKGROUND - GREEN (REFLECTIVE)

Figure 10-12
LIGHT RAIL STATION SIGN

On multi-lane roads the transverse bands shall extend across all approach lanes, and individual RXR symbols shall be used in each approach lane, excluding parallel exclusive left-turn or right-turn approach lanes.

2. Dynamic Envelope of a Light Rail Vehicle

The dynamic envelope of a light rail vehicle is the clearance on either side of a moving LRV such that no contact can take place due to any condition of design wear, loading, end or middle ordinate overhang, or anticipated failure such as air spring deflation or normal vehicle lateral motion.

The dynamic envelope of an LRV should be delineated on semi-exclusive, type b or non-exclusive, type c rights-of-way (Figure 10-13). The preferred method of delineating the dynamic envelope is by differential pavement or contrasting pavement texture, which may be supplemented by 4-inch solid yellow striping. Any crossing material or contrasting pavement texture used to delineate the track area shall extend to encompass the LRV's dynamic envelope. Rumble strips may be used to delineate the dynamic envelope.

An alternative method is to use a 4- or 8-inch solid white line as the delineating pavement marking (see description below). Lane striping may be used to mark the dynamic envelope of an LRV; however, lane striping shall not be located within the dynamic envelope.

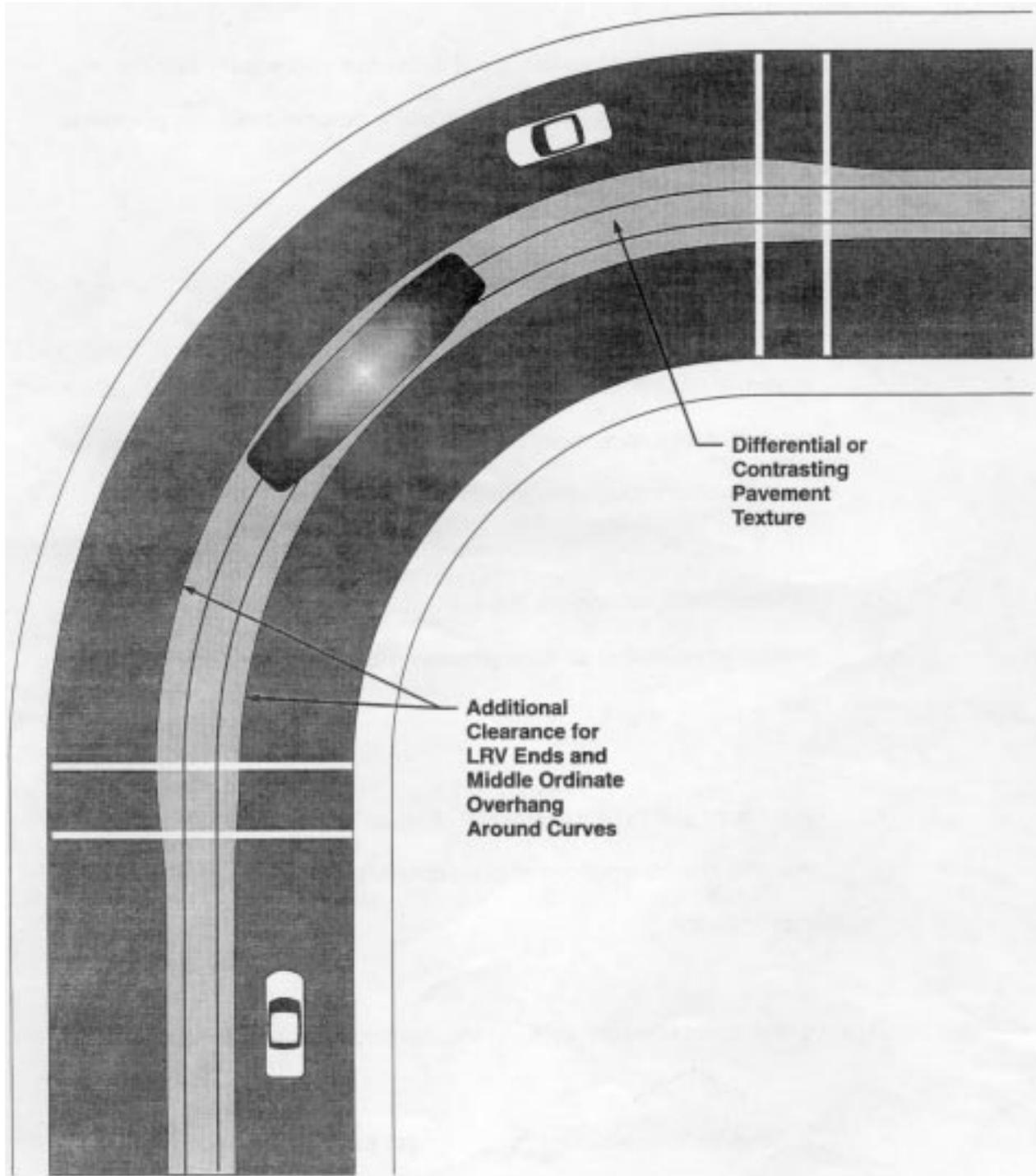


Figure 10-13
TYPICAL DYNAMIC ENVELOPE DELINEATION

Whenever the dynamic envelope of an LRV is not delineated in its entirety by differential pavement or contrasting pavement texture, the following pavement marking guidelines applications should be followed:

- a. Dynamic envelope delineation by pavement marking at intersections
 - In semi-exclusive corridors (type b) the dynamic envelope should be delineated for turning movements by a solid 8-inch white line and may be delineated for through movements by a solid 4-inch white line.
 - In mixed traffic applications (type c.1), the dynamic envelope of the LRV should be delineated for turning movements only, by a solid 8-inch white line.
 - In a Transit Mall (type c.2) or an LRT/Pedestrian Mall (type c.3) alignment, the LRV dynamic envelope shall be delineated in its entirety by a solid 4-inch white line.
- b. Dynamic envelope delineation by pavement marking between intersections
 - In mixed traffic applications (type c.1) with parking permitted:
 - * *Single lane or far right lane non-exclusive LRT right-of-way.* The right-hand side of the dynamic envelope should be marked by use of a white parking bracket "⏏" or "T" marking. If neither of these

symbols is used to delineate parking spaces, then the right-hand side of the dynamic envelope should be marked by a solid 4-inch line. The left-hand delineation would be a lane stripe or the center line of the roadway.

- * *Multi-lane and far left lane non-exclusive LRT right-of-way.* The right-hand side of the dynamic envelope should be marked by a lane stripe. The left-hand delineation would be the center line of the roadway.

- In mixed traffic applications (type c.1) with parking not permitted:
 - * *Single lane or far right lane non-exclusive LRT right-of-way.* The right-hand side of the dynamic envelope should be marked by use of a solid 4-inch white line, unless a 6-inch or higher curb separates the LRV's right-of-way from the sidewalk or a landscaped area. The left-hand delineation would be a lane stripe or the center line of the roadway.
 - * *Multi-lane and far left lane non-exclusive LRT right-of-way.* The right-hand side of the dynamic envelope should be marked by use of a lane stripe. The left-hand delineation would be the center line of the roadway.

- In Transit Mall applications (type c.2):
 - * *Single lane or far right lane non-exclusive LRT right-of-way.* The right-hand side of the dynamic envelope should be marked by use

of a solid 4-inch white line, unless a 6-inch or higher curb separates the LRV's right-of-way from the sidewalk or a landscaped area. The left-hand delineation would be a lane stripe to separate LRVs from the adjacent transit way travel or the center line of the roadway.

* *Multi-lane and far left lane non-exclusive LRT right-of-way.* The right-hand side of the dynamic envelope should be marked by a 4-inch wide line to separate LRVs from the adjacent transit way. The left-hand delineation would be the center line of the roadway.

- In LRT/Pedestrian Mall applications (type c.3), the LRV dynamic envelope shall be delineated in its entirety by a solid 4-inch white line.

3. Separation between Trackway and Roadway

To discourage vehicular encroachment onto the trackway, low-profile pavement bars, rumble strips, or rough textured pavement may be used. The low-profile pavement bars may be placed between the rails and/or between the tracks and the adjacent roadway. They shall not be placed within the marked crosswalk. Bars or rumble strips may be used parallel to the roadway striping or perpendicular to the direction of travel for automobiles where there is no curb separation. Examples of these two typical applications are shown in Figure 10-14.

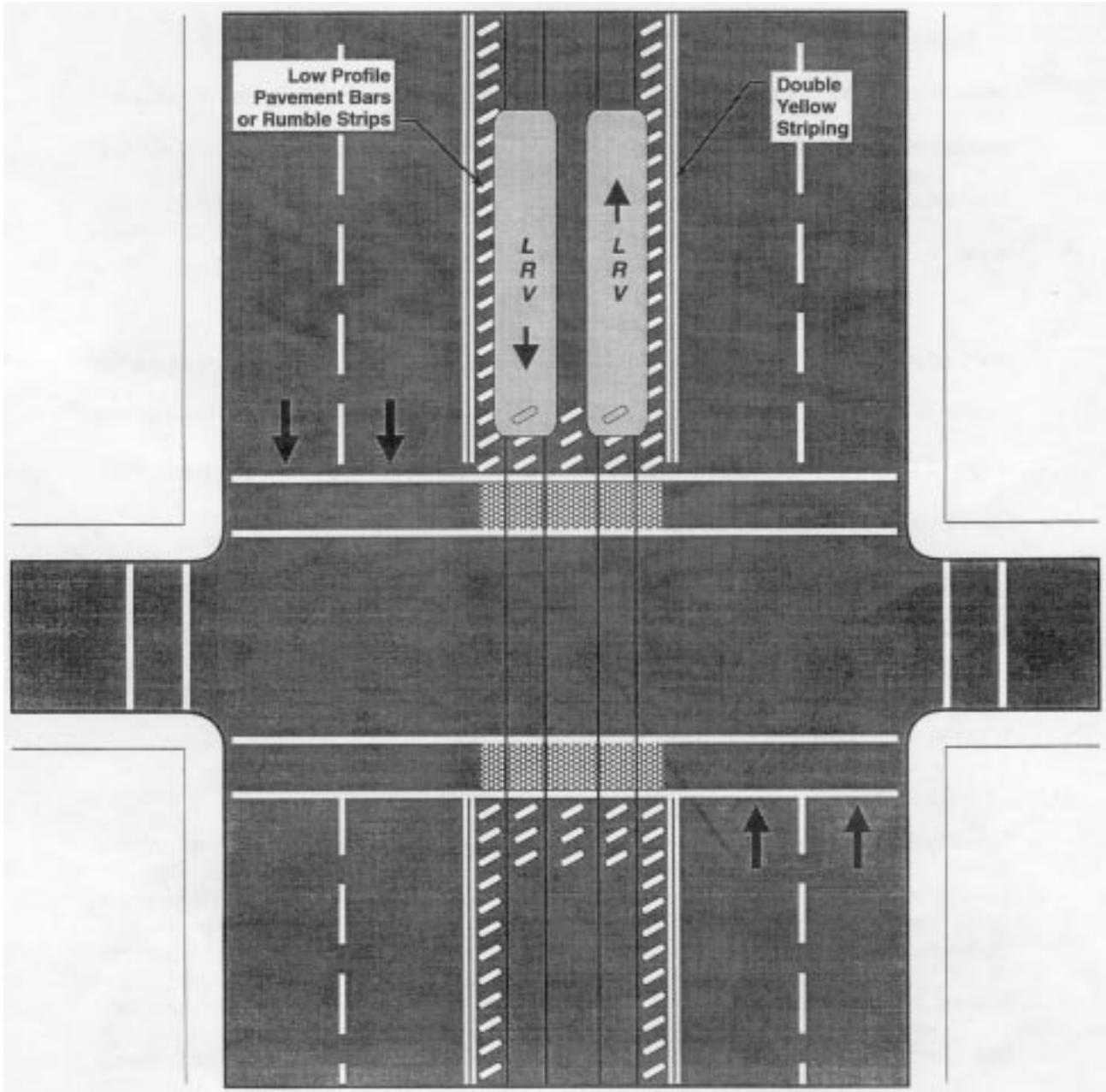


Figure 10-14
POSSIBLE APPLICATIONS OF LOW PROFILE PAVEMENT BARS

10-2.5 Pavement Markings - Pedestrians

1. Crosswalks

Pedestrian crossings of LRT tracks in street-running rights-of-way (i.e., **not** an isolated pedestrian crossings of LRT tracks) should be defined by two continuous, parallel lines (see section 3B-18) and/or contrasting pavement texture across the entire length of the crossing.

For added visibility, the area of the crosswalk between the outside edge of the dynamic envelope of an LRV and the nearest curb may be marked with white diagonal lines at 45° angle or with white longitudinal lines at 90-degree angle to the line of the crosswalk (See Section 3B-18 for typical width and spacing).

A LOOK LEFT or LOOK RIGHT legend may be painted in the crosswalk if the light rail is in a single-direction, single-track alignment; operating in a contra-flow lane; or is operating in some other unusual configuration.

Fencing and/or landscaping may be used to channelize pedestrian movements. Where pedestrian movements across the tracks are to be restricted, fencing on either side of the trackway, or between the LRT tracks may be used. The height of the fencing should not exceed a maximum of 42 inches, so as not to obstruct motorist, pedestrian, and LRV operator visibility. Security issues and pedestrian flow patterns should be considered when designing the fencing and/or landscaping features.

2. Dynamic Envelope of a Light Rail Vehicle

The LRV's dynamic envelope shall be delineated in semi-exclusive (type b) and non-exclusive (type c) corridors at pedestrian crossings. In a pedestrian or transit mall, the dynamic envelope shall be delineated in its entirety. Contrasting pavement texture should be used to identify an LRV's dynamic envelope through a pedestrian crossing and in a pedestrian or transit mall. A solid 4-inch wide line may be used as an alternative. Americans With Disabilities Act (ADA) approved, tactile warning strips can be considered a contrasting pavement texture, and their requirement may supersede the use of painted striping or other contrasting pavement texture.

10-2.6 Illumination at LRT Crossings

At LRT grade crossings with night service, illumination at and adjacent to the crossing should be installed to supplement other traffic control devices if an engineering study has determined that better visibility of an approaching LRV is needed. Illumination of LRT crossings should be sufficient to show the general layout of the crossing and immediate vehicular and/or pedestrian travel paths. The greatest concentration of illumination should occur at points that may be dangerous to vehicles or pedestrians (e.g., at or near the track area).

Luminaries shall be located and light therefrom so directed as to not interfere with aspects of the LRV signal system, with the field of view of the LRV operator, or with the field of view of a motorist. Recommended types and location of luminaries for grade crossing illumination are contained in Section 8B-5.

10-3 Grade Crossing Control Systems

10-3.1 Purpose and Meaning

Active traffic control systems inform motorists and pedestrians of the approaching or presence of light rail vehicles at grade crossings. They include automatic gates, flashing lights, automobile traffic signals, and other active warning traffic control devices. (See Section 8C for further explanation.)

LRT grade crossings with motor vehicles and pedestrians that occur along semi-exclusive right-of-way (type b.1, b.2) shall be controlled by automatic gates and flashing lights or traffic signals, depending upon LRV operating speeds and specific alignment features.

- Automatic gates and flashing lights shall be used where LRV speeds exceed 35 mph.
- Automatic gates and flashing lights may be used on semi-exclusive type b.1 right-of-way where LRV speeds are less than 35 mph. Light rail transit grade crossings along semi-exclusive type b.2, b.3, b.4, or b.5 right-of-way where speeds are 35 mph or less shall be controlled by traffic signals, unless a detailed traffic engineering study establishes a compelling reason for the use of stop signs.
- Light rail transit operations on non-exclusive alignments shall be controlled by traffic signals or stop signs. (See Section 10-2.1.6 for the roadway volume, speed and stopping sight distance requirements associated with stop sign control.)

Where light rail and railroads share a common right-of-way, the traffic control devices, systems and practices for railroad grade crossings shall govern. Signals or signing specific to LRT may be introduced into the existing control system if deemed necessary or appropriate by a traffic engineering study.

10-3.2 Automatic Gates

Automatic gates with flashing lights are appropriate when the following conditions exist:

- Automatic gates and flashing lights shall be installed at grade crossings within semi-exclusive (type b.1, b.2) alignments where LRV speeds exceed 35 mph.
- Gates shall control crossing movements at locations where light rail lines on semi-exclusive type b.1 rights-of-way cross roadways mid-block. Pedestrian gates shall also be installed at these locations where sight distance is inadequate.
- Gates shall be provided for semi-exclusive (type b.2) alignments where LRVs are permitted to operate at 10 mph more than the legal speed of parallel traffic.
- At locations where cross street traffic is controlled by automatic gates, gates may also be used to control conflicting left or conflicting right turn movements from parallel roadways.

- Gates may be appropriate in certain other situations where LRV speeds are less than 35 mph. Their need in such cases should be determined by an engineering study.
- The automatic gates described in Section 8C-4 shall be used for LRV gates. See Figure 8-7 for typical locations of automatic gates.

10-3.3 Flashing Light Signals

Post-mounted and cantilevered flashing light signals shall be used in the manner described in Sections 8C-2 and 8C-3 and shown in Figures 8-3 and 8-4. The flashing lights shall be used where automatic gates are installed, but also may be used separately.

Cantilevered flashing light signals may be used in the manner shown in Figure 8-4 where there is a need for additional emphasis or for better visibility to approaching traffic on multi-lane, stop-sign controlled approaches. Cantilevered flashing light signals shall be used at mid-block vehicular crossings. ***[Further research is needed to determine the exact definition for better visibility.]***

To avoid motorist confusion and general intersection "clutter," cantilevered flashing-light signals shall not be used adjacent to an intersection that is controlled by traffic signals with mast arms.

10-3.4 Traffic Signals

1. Gated Operation

When LRT automatic crossing gates are located within 200 feet of a motor vehicle intersection that is controlled by traffic signals, the traffic signals should be coordinated with the gate control by using a railroad preemption sequence. Coordination of the railroad gate control may be necessary for traffic signals located more than 200 feet from the crossing. Factors to be considered include: motor vehicle traffic volumes, approach speeds, and queue spillback; LRV headways and speeds; and gate down time.

There are two types of traffic signal preemption operations in conjunction with gated operations:

- (1) "Limited service" of vehicular and pedestrian movements that do not conflict with LRV movement.
- (2) Flashing red for all approaches, with possible exception of approach to grade crossing which may be solid red.

The "limited service" traffic signal preemption should be used unless all controlled traffic movements conflict with the LRV movement. If the LRT runs parallel to a railroad, the type of preemption operation used may be dictated by the nature of the railroad operation.

2. Semi-Exclusive Operation

To allow LRVs to proceed quickly and efficiently in a semi-exclusive (type b.1, b.2, b.3, b.4, b.5) right-of-way, LRT system designers and traffic engineers should provide enough

"look ahead" capability for LRVs to assure (to the extent possible) that once an LRV prepares to depart a station, it will be able to proceed to the next station stop without any major delays.

All LRV movements in semi-exclusive, non-gated alignments (type b.2, b.3, b.4, b.5) shall be controlled by separate LRV signal indications at grade crossings that are controlled by traffic signals. Traffic signal strategies to control LRV and vehicle movements include signals that do not give LRV priority at crossings, signals whose phasing is actuated by the approach of an LRV, and signals that allow LRV priority. A number of techniques are used to achieve priority, such as phase lengthening, phase shortening, phase skipping, and phase insertion. The priority is usually initiated after detecting the LRV at a predetermined distance in advance of one or a group of signals. Intersection traffic signal LRT phases can be activated by a variety of LRT detection devices. The preemption may occur within an established background signal cycle. Preemption within a background cycle is essential where traffic signals are coordinated along a roadway or within a network.

In a semi-exclusive alignment (type b) at a signalized intersection, motorists crossing the LRT tracks and then turning left shall receive a green left-turn arrow indication. Vehicular traffic traveling in the opposite direction shall receive a red ball. In this manner, the crossing will be cleared of left-turning motorists that may not be aware that an LRV is approaching. The left-turning motorists across the tracks should be serviced after the LRV has cleared the crossing, generally before the cross street phase.

3. Mixed Traffic

Vehicular traffic on mixed (non-exclusive, type c.1 and c.2) alignments shall be controlled by stop signs or traffic signals. (Section 10-2.1.6 describes stop-controlled LRT crossing applications.) Where the non-exclusive crossing is controlled by traffic signals, progression or prioritization may be provided for LRVs on a localized basis.

Separate LRT signals should also be installed when special conditions warrant their use. Such special conditions include but are not limited to: contra-flow operations, side-running operations, vehicular yellow intervals that are too short for LRV operation, and unique intersection geometries. Separate LRT signals may be used in non-exclusive alignments (type c.1, c.2) where special LRT phases are provided to accommodate turning LRVs or where required to ensure clearance of long LRV consists.

10-3.5 Light Rail Transit Signal Indications

Signal indications that govern only LRVs should have a format and color that are clearly different from conventional traffic signal displays. Where a light rail signal indication could cause motorists to be confused or misdirected, the signal indication should be positioned, shielded, optically programmed, or otherwise designed so that it is viewed exclusively by light rail operators and not by motorists. The light rail signal indication should convey the intended message to the LRV operator without any supplementary signs. It should contrast with vehicular signals in size, shape, color, aspect, and placement.

LRT signal indications should follow these guidelines:

- The signal installation should consist of a three-lens signal face oriented vertically, conveying the STOP, PREPARE TO STOP and GO indications. Alternatively, the LRT signal may consist of a two-section head with the STOP and GO indications only. If a two-section head is used, the GO indication should also be used in a flashing mode for conveying the PREPARE TO STOP indication. A flashing STOP indication may be used to convey change to the GO indication.
- Each LRT system should have a consistent signal display to avoid confusion to the LRV operator. The highway signaling convention with the STOP indication at the top and the GO indication at the bottom should be followed. The railroad signaling convention with the STOP indication at the bottom and the GO indication at the top shall be used only where LRT and railroad share track, and the railroad has already adopted the STOP-at-the-bottom signaling convention; this arrangement shall not be used in median-running semi-exclusive or non-exclusive operations.
- The GO indication should be displayed as a vertical (proceed straight) or angled (turn) bar. The PREPARE TO STOP indication should be displayed as a flashing triangle. Where an LRV operator could confuse the triangle aspect with a circular (ball) aspect from a distance, the two section head, LRT signal may be used. If a two section head is used, the PREPARE TO STOP indication may be displayed by a flashing operation of the GO indication. The STOP indication should be displayed as a horizontal bar. Figure 10-15 illustrates various configurations of the

LRT signals for use at points where there is a single LRT route and where two or three LRT routes diverge.

- The color for all LRT signal indications should be lunar white but may be incandescent white. Amber may be used for the PREPARE TO STOP and/or STOP indication. LED (Light-Emitting Diode) displays may be used.
- The size of the signal lenses that govern LRVs should be 12 inches. In tight urban situations with LRV speeds of 25 mph or less, 8-inch lenses may be used. The shape of the signal housing should be rectangular (or square). The color of the signal housing shall be dark, preferably black, with a visor for each lens. In locations with visibility limitations for the LRV operator, backplates may be used.
- The primary LRT signal head should be located on the near side of the at-grade crossing or intersection. When special conditions exist, such as at approach blocks that are equal to or shorter than the maximum train length, the far side location should be used for the placement of the primary LRV signal. Specific site considerations may require additional supplementary single-aspect LRT signal heads displaying only the GO indication.
- The LRT signal heads should be separated vertically and/or horizontally from the nearest traffic signal head or pedestrian signal head for the same approach by a minimum of 8 feet.

	<i>Three-Lens Signal (Recommended)</i>	<i>Two-Lens Signal (Alternate)</i>
<p>SINGLE LRT ROUTE</p> 	<p>STOP </p> <p>PREPARE TO STOP </p> <p>GO </p>	<p> STOP</p> <p> GO</p>
<p>TWO LRT ROUTE DIVERSION</p> 	<p></p> <p></p> <p> </p>	<p></p> <p> </p>
	<p></p> <p></p> <p> </p>	<p></p> <p> </p>
<p>THREE LRT ROUTE DIVERSION</p> 	<p></p> <p></p> <p>  </p>	<p></p> <p>  </p>

Notes:

All Aspects are White.

(1) Could be in Single Housing.

(2) *Stop* lens may be used in flashing mode to indicate *Prepare to Go*.

(3) *Go* lens used in flashing mode to indicate *Prepare to Stop*.

**Figure 10-15
LRT SIGNAL ASPECTS**

- Light rail signals shall be installed within the cone of vision of the LRV operators and shall be clearly visible with no physical obstructions. The cone of vision for LRV operators should be 25 degrees to each side of the track center line, for a total of 50 degrees.
- Light rail signals for both directions of travel on the same track should only be installed on single-track segments where regular two-way operation occurs. Installation of LRT signals for reverse-running operation should be minimized, and the use of dwarf signals is recommended.
- Where both LRT signals and LRT switch position indications (for diversion routes) are used in tandem for street operations (i.e., where interlocking control and the traffic signal control are not integrated), the switch position signal indication should also be lunar white, as shown in Figure 10-16. The size of the signal lenses for LRT switch signals should be a minimum of 8 inches square. The color of the signal housing shall be dark, preferably black, with a visor for each lens. In locations with visibility limitations for the LRV operator, backplates may be used.

10-3.6 Pedestrian Crossing Control Systems

Pedestrian crossing control systems are another important aspect of successful integration of LRT into city streets. Interactions between pedestrians and LRVs are significantly different than those between motorists and LRVs. In general, as operators of motor vehicles, motorists tend to be more acutely aware of their dynamic environment. Pedestrians, conversely, operating largely in the relatively safe venue of the protected

<i>Switch Position Signal Aspect</i>		
<i>LRT Route</i>	<i>Diversion Speed of 10 MPH or Less</i>	<i>Diversion Speed of More Than 10 MPH</i>
		
		
		

LRT ROUTE DIVERSION SIGNALS

- All Aspects are White
- All Aspects are 8-inch square
- Could be in Single Housing

Figure 10-16
SEPARATE SIGNAL INDICATIONS FOR DIVERSION SWITCH POSITIONS

sidewalk area, do not routinely share the same continuous, attentive edge. W

the travel path of motor vehicles or LRVs, however, pedestrians should shift to a similar state of awareness as that exhibited by motorists. However, this is not always the case. Also, unlike motor vehicles, LRVs can not swerve or stop quickly enough to compensate for the pedestrians who ignore pedestrian signals or cross tracks at random.

For these reasons, pedestrian crossing control systems such as the following should be used to channel and/or control pedestrian access to and/or across LRT tracks, supplementing with signs or signals:

- Signalized Pedestrian Crossing
- Unsignalized Pedestrian Crossing
- Pedestrian Automatic Gates
- Swing Gates
- Curbside Pedestrian Barriers
- Bedstead Barriers
- Z-Crossing Channelization

Common LRV/pedestrian incidents involve pedestrians crossing unimpeded across the LRT right-of-way. The at-grade crossing control systems described in this section are designed to alert the pedestrian of a situation where special attention must be given. They are designed to warn, channelize and/or block pedestrians from their desired paths of travel. These systems also channel pedestrians to specific areas of the crossings and away from vehicular traffic. The systems help to inform pedestrians of potentially hazardous situations for which extra care is warranted.

As pedestrian risk of a collision with an LRV varies, different pedestrian control systems should be used. The potential level of risk is a function of pedestrian volumes, LRV speeds, crossing configuration, stopping sight distance, adjacent land use, existence of passenger transfer, and other factors that may impact pedestrian safety.

[Further research is needed to quantify the pedestrian's potential level of risk.]

1. Signalized Pedestrian Crossing

At signalized intersections where pedestrians cross LRT tracks, the primary control device (for pedestrians crossing the LRT tracks) shall be the standard symbolic WALK/DON'T WALK pedestrian signal indication shown in Figure 4-3, Section 4D-4. The primary warning sign for signalized pedestrian crossings of LRT tracks shall be the 24-inch LIGHT RAIL TRANSIT CROSSING (W10-5) sign.

At those locations where light rail runs adjacent to a railroad, additional pedestrian signals should be installed between the two sets of tracks where space permits to define each system's right-of-way. A pedestrian safety area should be clearly marked between the light rail and railroad tracks to provide the necessary queuing area.

2. Unsignalized Pedestrian Crossing.

At non-gated, unsignalized (without pedestrian WALK/DON'T WALK signals), pedestrian-only, LRT crossings of semi-exclusive type b.1 and b.2 right-of-way, the primary warning device shall be the flashing light signal assembly shown in Figure 10-17, Option A. This signal assembly should be mounted adjacent to the crossing facing each direction. A 24-

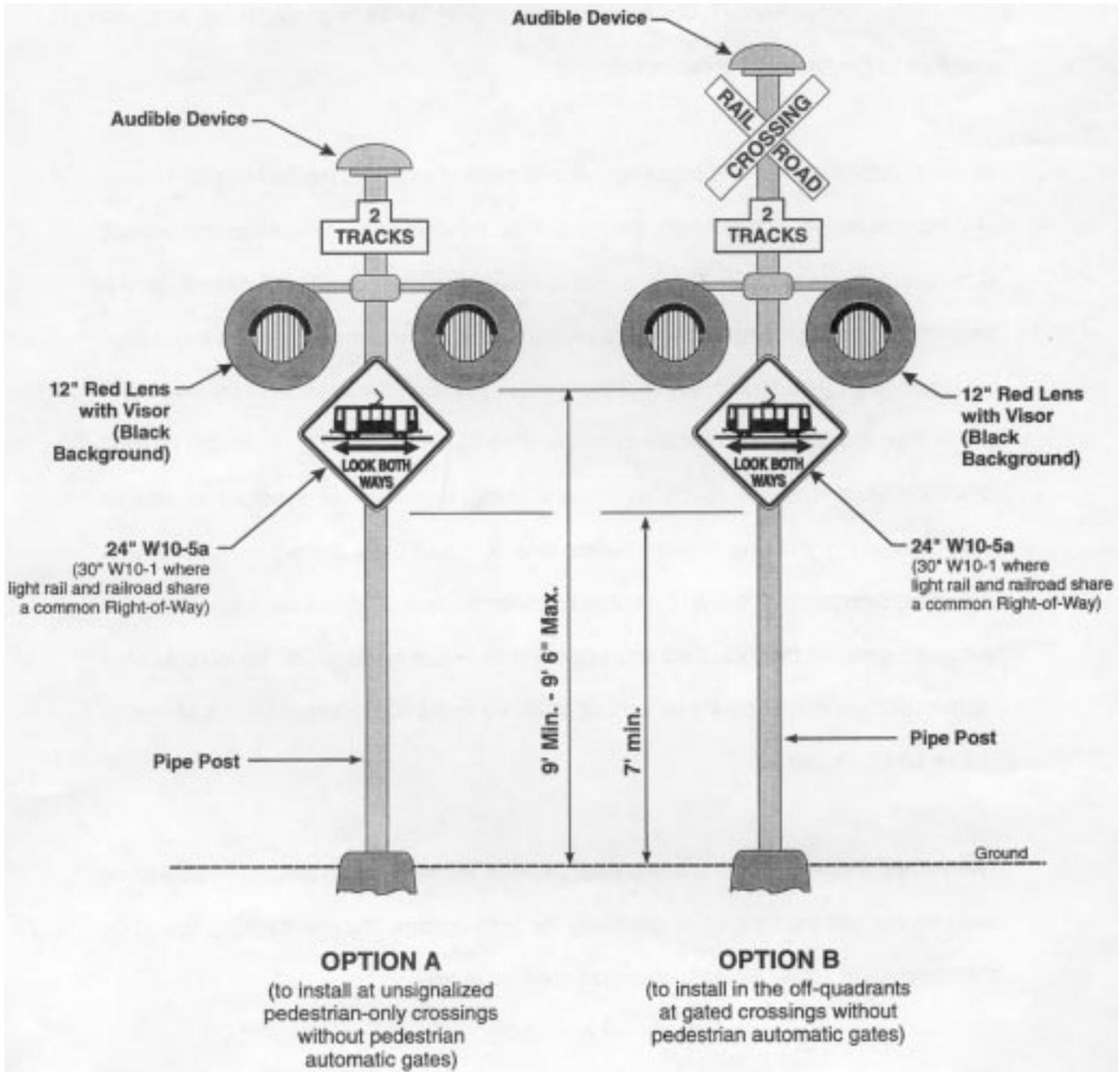


Figure 10-17
 PEDESTRIAN CROSSING WARNING DEVICES
 Flashing Light Signal Assembly

inch LIGHT RAIL TRANSIT CROSSING/LOOK BOTH WAYS sign (W10-5a) shall be attached to the flashing light assembly.

At motor vehicle, gated, LRT crossings without pedestrian gates, the flashing light signal assembly, shown in Figure 10-17, Option B, shall be used in the two quadrants without vehicle automatic gates. These signal devices shall be installed adjacent to the pedestrian crossing facing out from the tracks. The signal assembly includes a standard crossbuck sign (R15-1) and, where there is more than one track, an auxiliary inverted T shape sign indicating the number of tracks (R15-2). A 24-inch LIGHT RAIL TRANSIT CROSSING/LOOK BOTH WAYS (W10-5a) warning sign shall be installed at all four quadrants of the crossing to warn pedestrians of the LRT. In the two quadrants with vehicle automatic gates, the W10-5a shall be mounted on a sign post separately from the automatic gate. In the two quadrants without vehicle automatic gates, the W10-5a may be mounted separately on a sign post or attached to the signal assembly, as shown in Figure 10-17, Option B.

Twelve-inch diameter red lenses with visor and dual wattage bulbs (25w/150w) should be used on the flashing light signal assembly for both options. Normal flashing operation shall operate at 150w. Backup operation shall be at 25w.

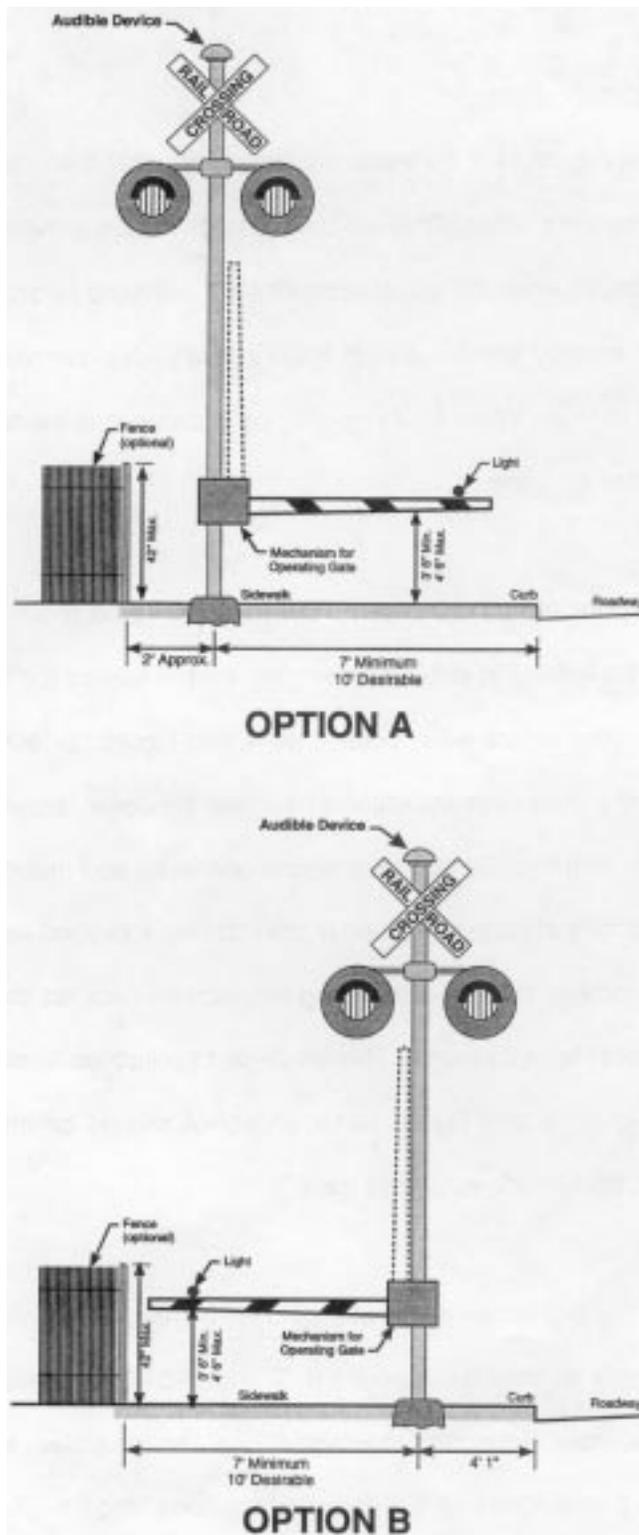
At unsignalized pedestrian LRT crossings of semi-exclusive type b.3, b.4, b.5 and non-exclusive (type c) right-of-way where LRVs operate two-way, the primary warning device shall be the 24-inch LIGHT RAIL TRANSIT CROSSING/LOOK BOTH WAYS (W10-5a) sign.

3. Pedestrian Automatic Gate

Pedestrian automatic gates are the same as standard automatic grade crossing gates except the gate arms are shorter. They are utilized to physically prevent pedestrians from crossing the LRT tracks when the automatic gates are activated by an approaching LRV. This type of barrier method may be used in areas where pedestrian risk of a collision with an LRV is medium to high. When LRV stopping sight distance is inadequate, pedestrian automatic gates shall be used.

Where right-of-way conditions permit, the vehicle automatic gate should be located on the inside (behind) of the sidewalk, so that the arm will extend across the sidewalk, blocking the pedestrian way (See Figure 8-8 in Section 8C-4, and Figure 10-19, Option A). Longer and lighter gate arms make this installation feasible. However, experience suggests a maximum gate arm length of 38 feet for practical operation and maintenance. At those crossings requiring the gate arm to be longer than 38 feet, a second automatic gate shall be placed in the roadway median. Extending the gate arm across the sidewalk blocks two of the four pedestrian quadrants. The single-unit pedestrian automatic gate shown in Figure 10-18, Option A and Figure 10-19, Option A should be installed across the tracks, opposite to the vehicle automatic gate.

As an alternative, the pedestrian automatic gate may share the same assembly with a vehicle automatic gate as shown in Figure 8-9, Section 8C-4 and Figure 10-19, Option B. In this case a separate driving mechanism should be provided for the pedestrian automatic gate so that a failure of the pedestrian automatic gate will not affect vehicle automatic gate operations. The single-unit pedestrian automatic gate shown in Figure 10-



OPTION A

OPTION B

Figure 10-18
SINGLE UNIT PEDESTRIAN AUTOMATIC GATES

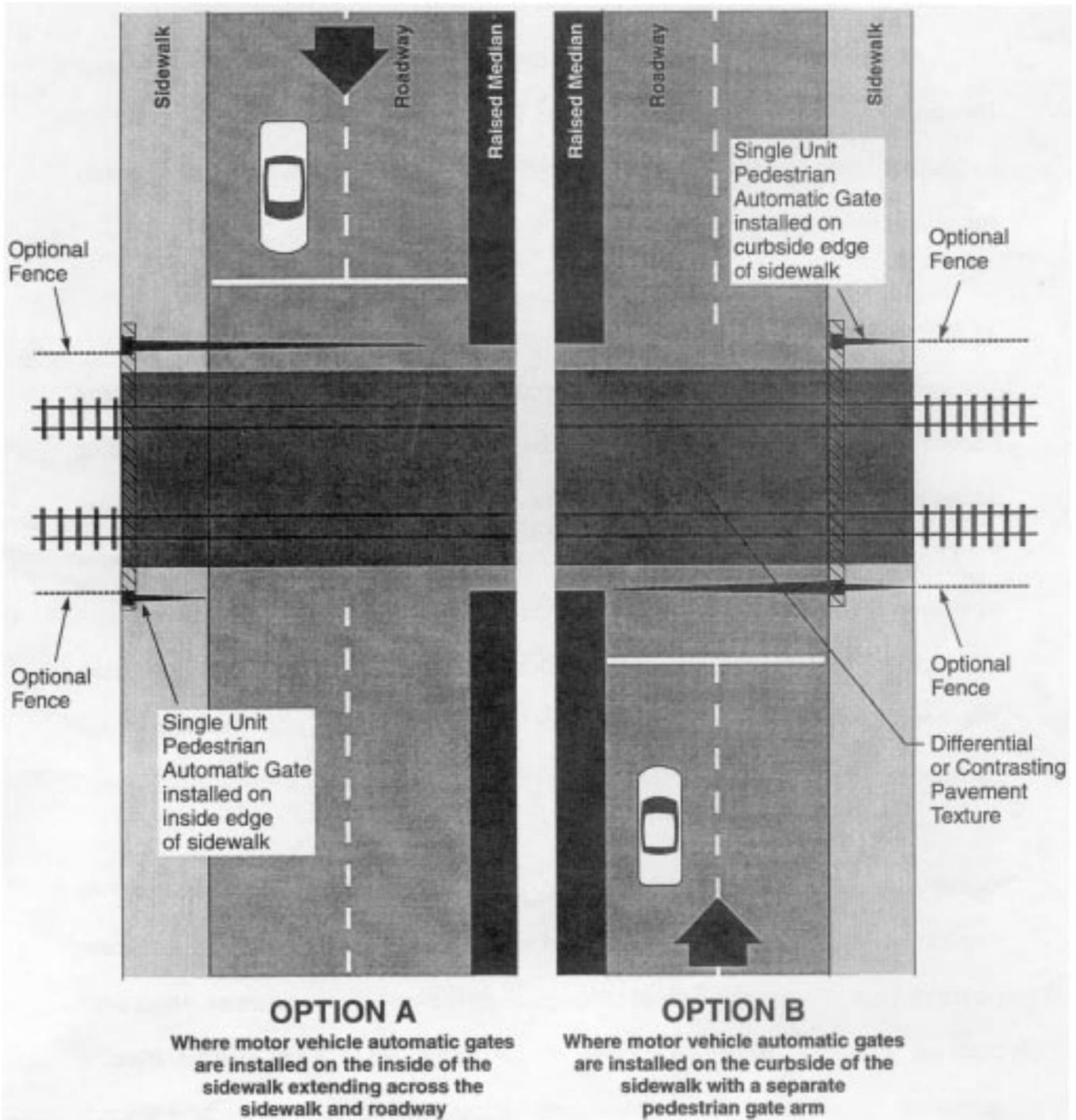


Figure 10-19
 PLACEMENT OF PEDESTRIAN AUTOMATIC GATES

18, Option B and Figure 10-19, Option B should be installed across the tracks, opposite to the vehicle automatic gate and pedestrian automatic gate assembly.

The possibility of trapping pedestrians in the LRT right-of-way when four-quadrant pedestrian gates are installed should be minimized. Clearly marked pedestrian safety zones and escape paths within the crossing shall be established.

4. Swing Gate

The swing gate (sometimes used in conjunction with flashing lights and/or bells) alerts pedestrians to the LRT tracks that are to be crossed and forces them to pause, thus acting as a deterrent to running freely across the tracks without unduly restricting exit from the LRT right-of-way. The swing gate requires pedestrians to pull the gate in order to enter the crossing and to push the gate to exit the protected track area; therefore, a pedestrian cannot physically cross the track area without pulling and opening the gate. The gates shall be designed to return to the closed position after passage of the pedestrian. Figure 10-20 illustrates the typical swing gate configuration.

Swing gates may be used at pedestrian-only crossings, on sidewalks, and near stations (especially if the station is a transfer point with moderate pedestrian volumes) where pedestrian risk of a collision with an LRV is medium to high (i.e., moderate stopping sight distance, moderate pedestrian volume, double tracks, etc.). They may be used at pedestrian crossings of either single (one- or two-way operations) or double track alignments.

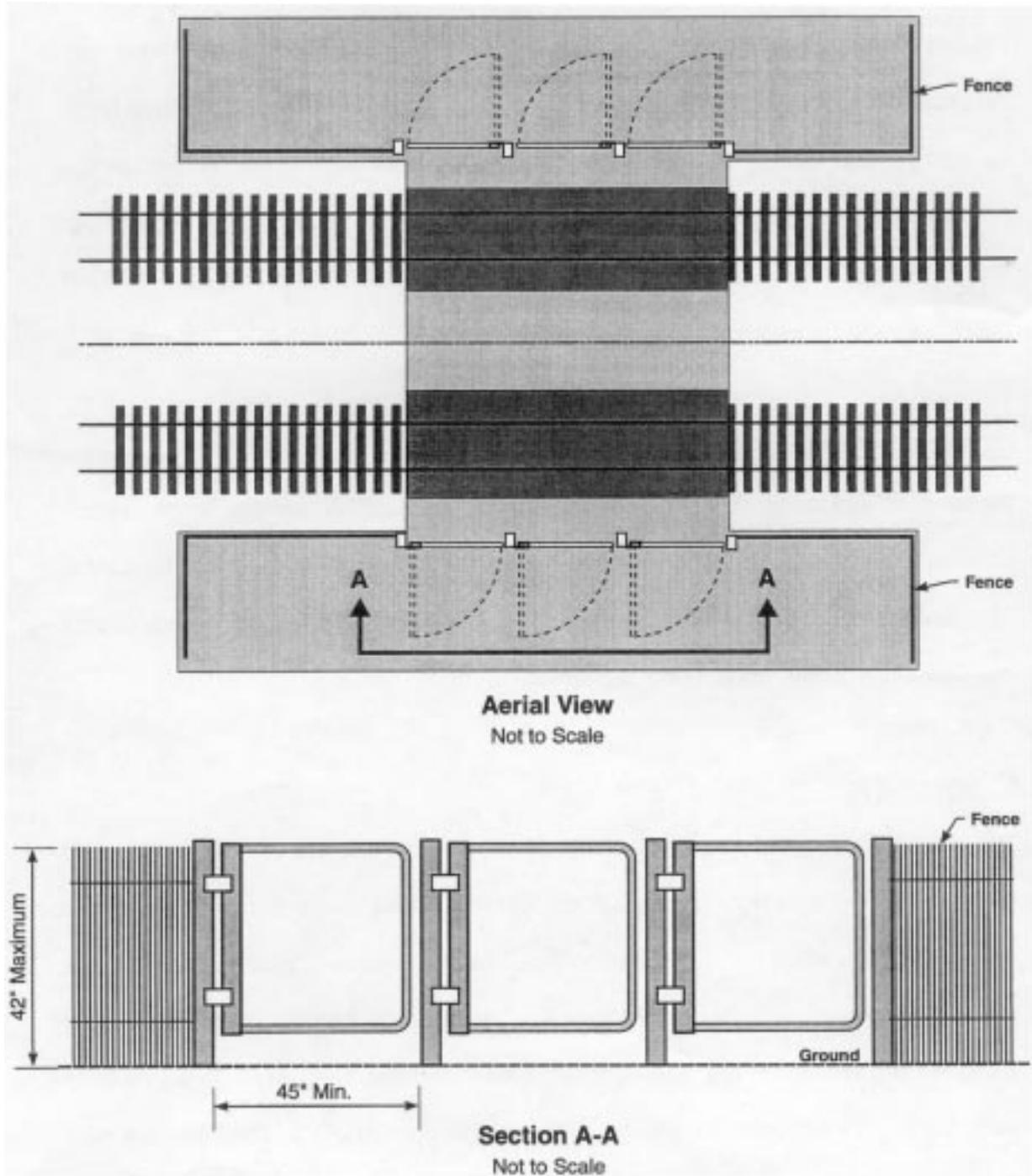


Figure 10-20
SWING GATES

The use of swing gates should be supplemented with proper signing mounted on or near the gates. These include the LIGHT RAIL TRANSIT CROSSING/LOOK BOTH WAYS (W10-5a) sign (where LRVs operate two-way) or an LRV activated warning sign and/or flashing light signal assemblies. When LRVs operate in a single-track, two-way alignment, an LRV activated internally illuminated sign with the legend SECOND TRAIN - LOOK LEFT/RIGHT (W10-7) should be installed to supplement swing gates.

5. Curbside Pedestrian Barriers

Between LRT crossings, curbside barriers (landscaping, bedstead barriers, fences, and/or bollards and chains) should be provided along side-running LRT alignments for contra-flow operations or two-way operations along a one-way street. They may be provided for one-way side-running normal flow alignments.

6. Bedstead Barrier

The "bedstead" concept may be used in tight urban spaces where there is no fenced-in right-of-way, such as a pedestrian grade crossing at a street intersection. The barricades are placed in an offset (i.e., maze-like) manner that requires pedestrians moving across the LRT tracks to navigate the passageway through the barriers. They should be designed and installed to turn pedestrians toward the approaching LRV before they cross each track, forcing them to look in the direction of oncoming LRVs. The barriers should be also used to delineate the pedestrian queuing area on both sides of the track area. Figure 10-21 illustrates a possible application of bedstead barriers. The same effect can be accomplished by using bollards and chains.

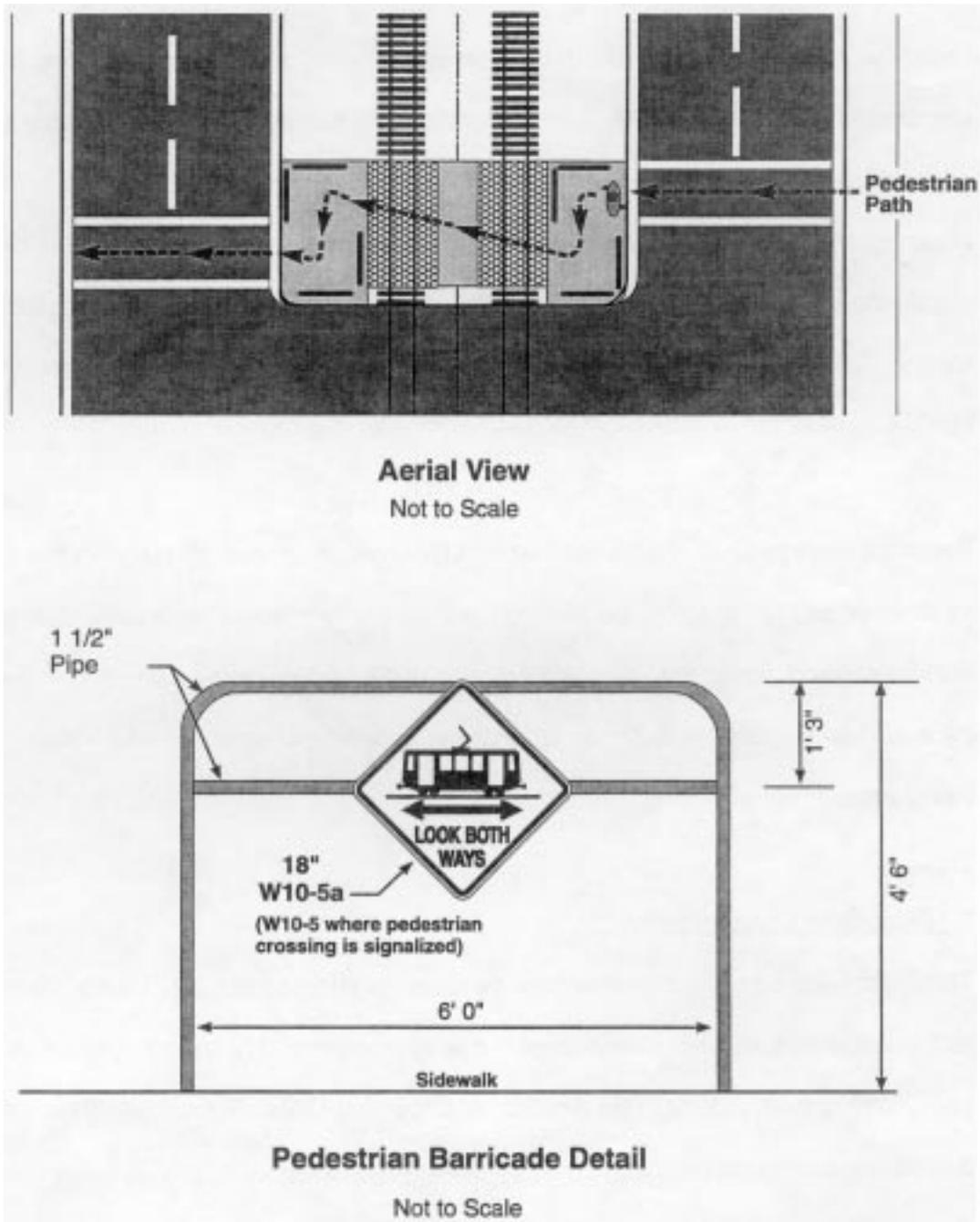


Figure 10-21
BEDSTEAD BARRIERS AT LRT CROSSING

Bedstead barriers may be used in crossings where pedestrians are likely to run unimpeded across the tracks, such as stations or transfer points, particularly where pedestrian risk of a collision with an LRV is low to medium (i.e., excellent to moderate stopping sight distance, double tracking, low pedestrian volume, etc.). The barriers should be used in conjunction with flashing lights, pedestrian signals and appropriate signing. Bedstead barriers may also be used in conjunction with automatic gates in high risk areas.

Bedstead barriers shall not be used when LRVs operate in both directions on a single-track since pedestrians may be looking the wrong way in some instances. During LRV reverse-running situations, pedestrians also look in the wrong direction; however, because reverse running is performed at lower speeds, this should not be a deterrent to this channeling approach.

7. Z-Crossing Channelization

The Z-Crossing controls movements of pedestrians approaching LRT tracks. Its design and installation turn pedestrians toward the approaching LRV before they cross each track, forcing them to look in the direction of oncoming LRVs. Figure 10-22 illustrates the Z-Crossing configuration.

Z-Crossing channelization may be used at crossings where pedestrians are likely to run unimpeded across the tracks, such as isolated, mid-block, pedestrian-only crossings,

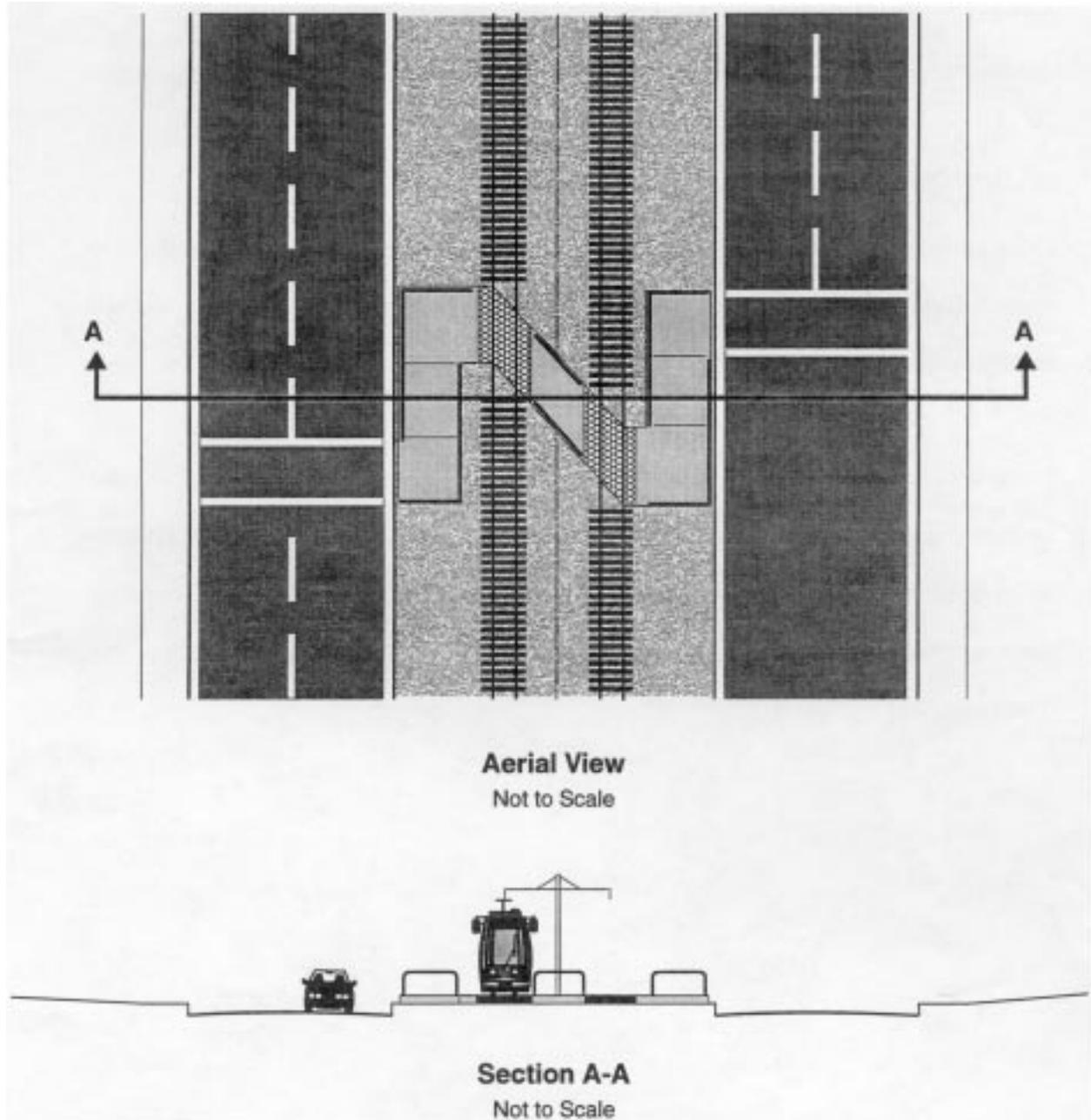


Figure 10-22
Z CROSSING CHANNELIZATION

particularly where pedestrian risk of a collision with an LRV is low to medium (i.e., excellent to moderate stopping sight distance, double tracking, low pedestrian volume, etc.).

Z-Crossings used with pedestrian signals create safer environments for pedestrians than when Z-Crossings are used alone. This type of channelization device may also be used in conjunction with automatic gates in high-risk areas.

The Z-Crossing shall not be used when LRVs operate in both directions on a single-track since pedestrians may be looking the wrong way in some instances. During LRV reverse-running situations, pedestrians also look in the wrong direction; however, because reverse running is performed at lower speeds, this should not be a deterrent to this channeling approach.