



RAILROAD GRADE CROSSINGS

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Overview

A railroad grade crossing is the intersection of a roadway and a railroad, at grade. Trains have the right-of-way at grade crossings, with two levels of warning used for vehicular traffic: active grade crossings and passive grade crossings. Active grade crossings include flashing lights and may include gates, while passive grade crossings do not use flashing lights or gates.

Traffic control devices (*i.e., signs, pavement markings, flashing lights, etc.*) and systems used at all grade crossings open to public travel shall be consistent with the design and application of the standards contained in the Manual on Uniform Traffic Control Devices (MUTCD), Part 8.

All at-grade crossings must have correct passive or active control treatments in accordance with MUTCD. Military installations should all on-base crossings comply with these requirements.

Passive traffic control systems, consisting of signs and pavement markings only, identify and direct attention to the location of the grade crossing advising road users to slow down, yield, or stop at the grade crossing.

Active traffic control systems are equipped with active devices that warn road users of the approach or presence of rail traffic at grade crossings. Examples of some the systems used are four-quadrant gates, automatic gates, flashing light signals, traffic control signals, actuated blank-out and variable message signs, and other active traffic control devices.

Railroads on military bases are often government owned, but can also be owned by a commercial railroad operator, such as Norfolk Southern or CSX. While commercial railroad operators maintain the responsibility for installation and maintenance of crossbuck signs at passive crossing and for the design, construction, operation, and maintenance of railroad crossing signals at grade crossings, state transportation and regulatory agencies have the responsibility to assure that the standards set forth in the MUTCD and elsewhere in federal regulations are followed. Government-owned railroad lines that travel through a military base are often the responsibility of that base to maintain including the crossings.

This bulletin is intended to provide information on traffic control requirements for railroad grade crossings, as well as basic geometric design information for crossings. Unified Facilities Criteria (UFC) 4-860-03, *Railroad Track Maintenance and Safety Standards*, 2008, Chapter 10 has additional information on grade crossings.

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Geometric Design

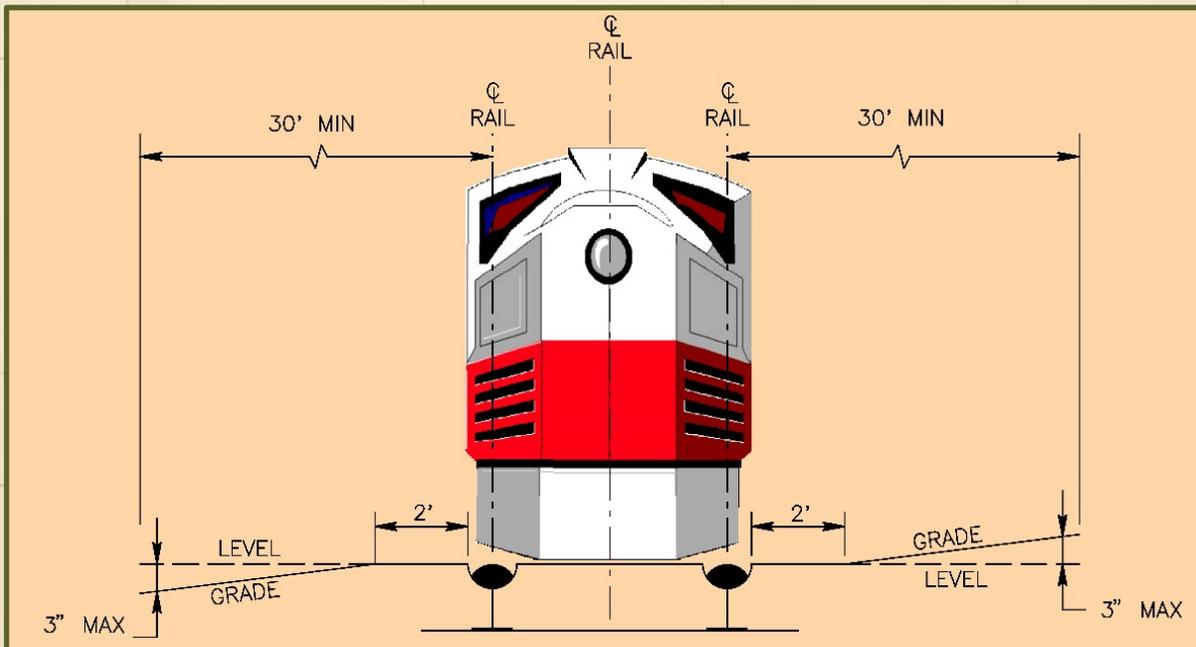
Ideally, a grade crossing should be aligned at a right angle with no nearby intersections or driveways. This layout enhances the driver's view of the crossing and the tracks, reduces conflicting vehicular movements from crossroads and driveways, and is preferred for bicyclists. To the extent practical, crossings should not be located on either highway or railroad curves. Roadway curves inhibit a driver's view of a crossing ahead, and railroad curvature can inhibit a driver's view of the tracks approaching the crossing.

Where roadways that are parallel with main tracks intersect roadways that cross main tracks, provide sufficient distance such that intersection queues do not extend over the railroad tracks (refer to image at right). If this is not possible, consider combining the railroad grade crossing signal with the intersection traffic signal. The 2009 MUTCD adds a signal warrant for an intersection near a grade crossing; this warrant could justify signalization for an intersection where other traditional warrants would not justify signalization.



The actual intersection of a roadway and railroad should be as level as practical. Vertical curves should be of sufficient length to provide an adequate view of the crossing.

To prevent drivers of low-clearance vehicles from becoming caught on the tracks, the crossing surface should be at the same plane as the top of the rails for a distance of 2 feet outside of the rails. The surface of the highway should not be more than 3 inches higher than or lower than the top of the nearest rail at a point 30 feet from the rail unless track superelevation makes a different level appropriate. Vertical curvature should be used to change the roadway profile from the highway grade to a level plane at the elevation of the rails.



Sight Distance

Sight distance is a primary consideration at locations without active warning devices. There are two sight distance related scenarios that can occur and must be considered at crossings without active warning devices:

- The driver on the roadway can observe the approaching train in a sight line that will allow the vehicle to pass through the grade crossing prior to the train's arrival at the crossing (Case A).
- The driver on the roadway can observe the approaching train in a sight line that will allow the vehicle to stop prior to the tracks (Case B).

Both of these maneuvers are illustrated in figure 1 and are considered 'Case A' sight distance (applicable to approaching vehicles). Another situation, considered 'Case B', represents the departure sight distance. When a vehicle has stopped at a railroad crossing, the next maneuver is to depart from the stopped position. The vehicle driver should have sufficient sight distance along the tracks to accelerate the vehicle and clear the crossing prior to the arrival of a train, even if the train comes into view just as the vehicle starts. Figure 2 illustrates this requirement.

FIGURE 1: Case A – Moving Vehicle to Safely Cross or Stop at Railroad Crossing

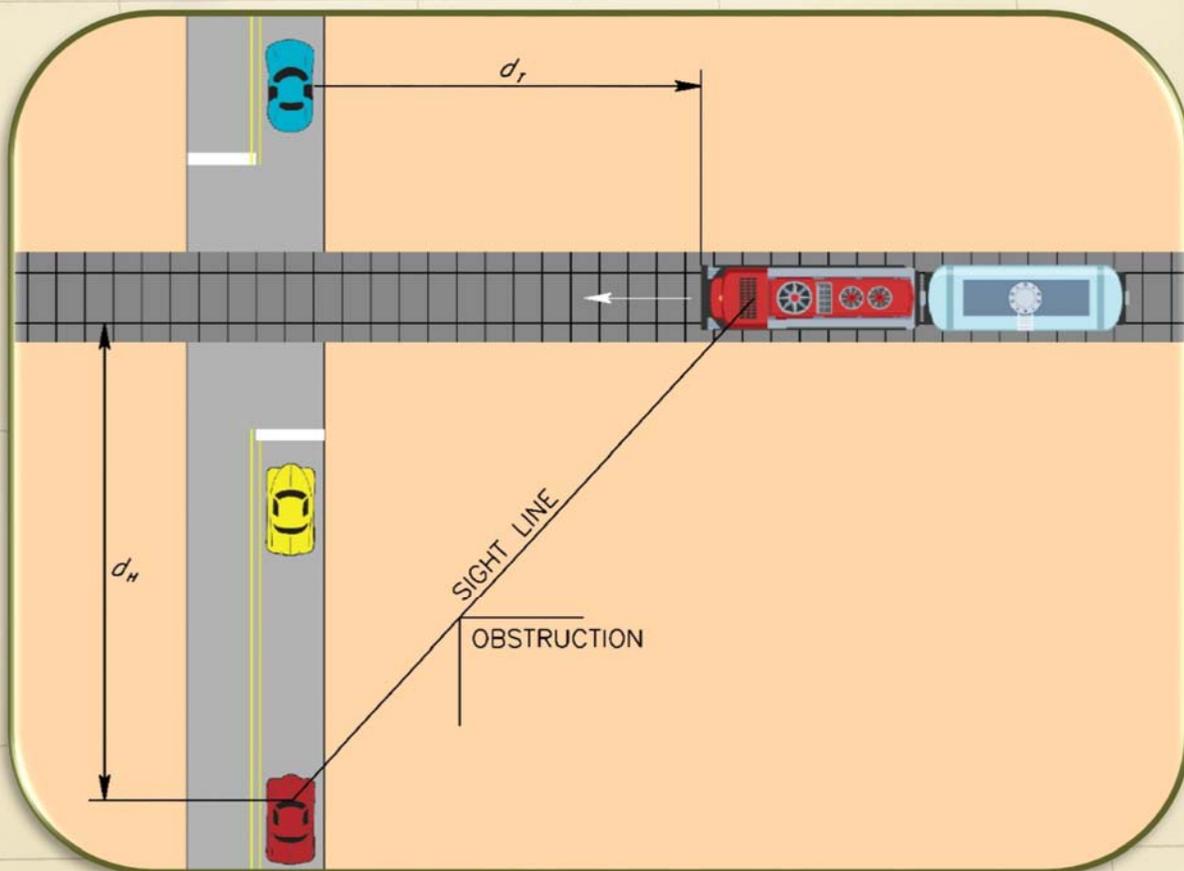
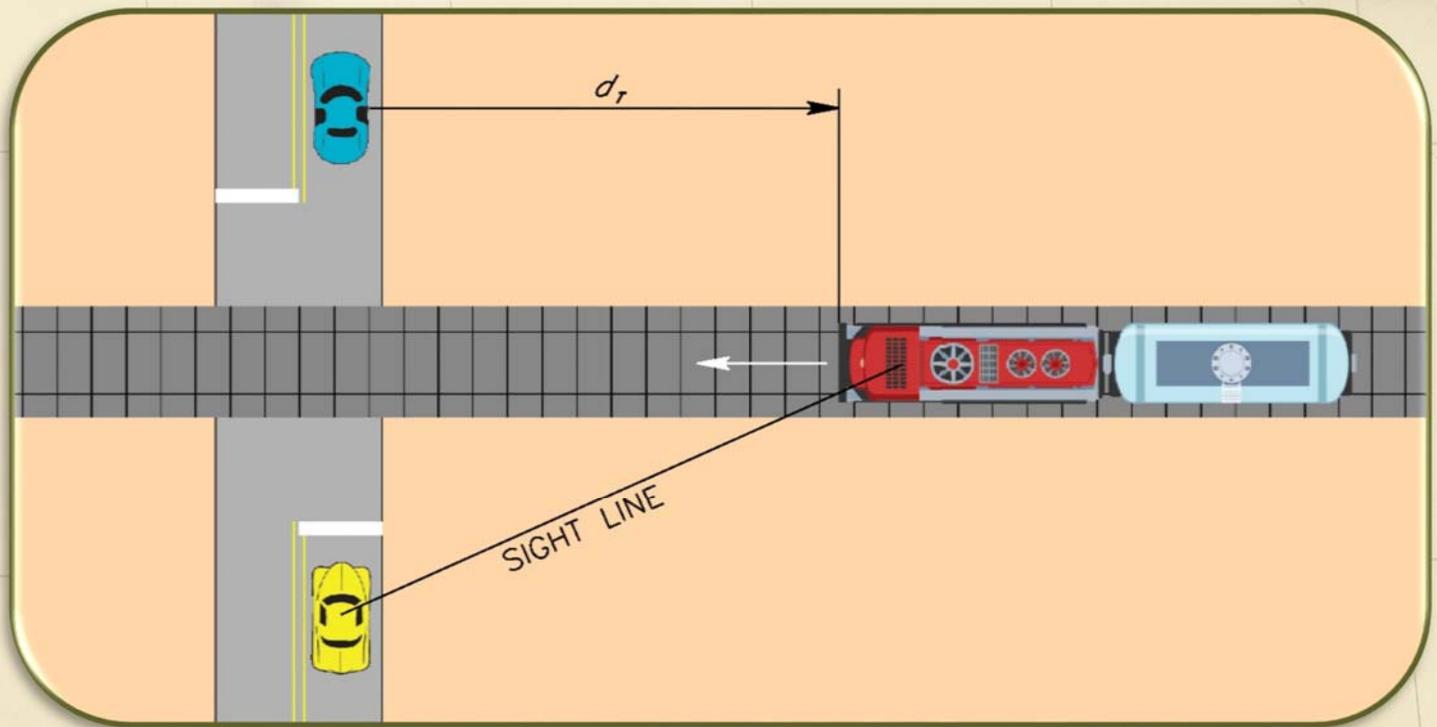
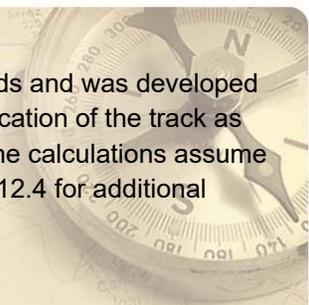


FIGURE 2: Case B – Departure of Vehicle from Stopped Position to Cross Single Railroad Track



The availability of sight distance will determine whether a grade crossing requires a stop condition or a yield condition. Per the MUTCD, Yield control is the default condition to minimize delays to traffic; however, the required sight distance must be provided. If the sight distance for Case A (figure 1) can be attained, the crossing can be posted with Yield control. If only Case B (figure 2) sight distances can be attained, the crossing should be posted with Stop control. If neither Case A nor Case B can be attained, consider either lowering the train speed to such that sight distance for a lower train speed can be attained for Case B, eliminating the sight distance limitation, or converting to an active warning system.

The table below shows the calculated required sight distances for varying roadway and railroad speeds and was developed for a truck crossing a track at a right angle to the roadway. Railroad speeds are based on the classification of the track as determined by the Federal Railroad Administration (FRA). Refer to FRA's website for more details. The calculations assume the distance from the stop line to the nearest rail is 15 feet. Refer to AASHTO Green Book Section 9.12.4 for additional variables assumed, as well as the equations used to calculate the sight distance values.



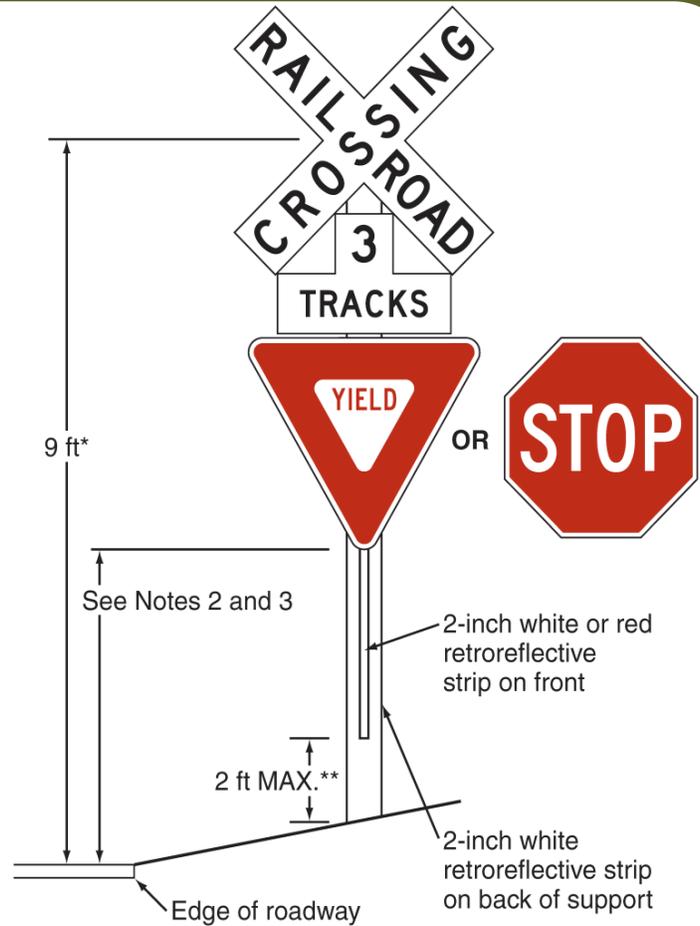
Design Sight Distance for Combination of Roadway and Train Vehicle Speeds; 73.5-ft Truck Crossing a Single Set of Tracks at 90 Degrees (from AASHTO Green Book, Table 9-32)

Train Speed (mph)	Case B	Case A								
	Departure From Stop (d_T) [ft]	Moving Vehicle								
		Vehicle Speed (mph)								
	0	10	20	30	40	50	60	70	80	
		Distance along Railroad from Crossing (d_r) [ft]								
10	255	155	110	102	102	106	112	119	127	
20	509	310	220	203	205	213	225	239	254	
30	794	465	331	305	307	319	337	358	381	
40	1019	619	441	407	409	426	450	478	508	
50	1273	774	551	509	511	532	562	597	635	
60	1528	929	661	610	614	639	675	717	763	
70	1783	1084	771	712	716	745	787	836	890	
80	2037	1239	882	814	818	852	899	956	1017	
90	2292	1394	992	915	920	958	1012	1075	1144	
		Distance along Highway from Crossing (d_H) [ft]								
		69	135	220	324	447	589	751	931	

Passive Grade Crossings

As previously stated, passive traffic control systems consist of signs and pavement markings only. Per the MUTCD Section 8B, a Crossbuck assembly at a passive grade crossing shall consist of a Crossbuck (R15-1) sign, a Number of Tracks (R15-2P) plaque if two or more tracks are present, and either a YIELD (R1-2) or STOP (R1-1) sign. Before installing a YIELD sign, an engineering study should be performed to determine if a STOP sign is warranted due to insufficient intersection sight distance. Figure 3 illustrates a Crossbuck assembly with a YIELD or STOP sign on the Crossbuck sign support. Alternatively, figure 4 illustrates a Crossbuck assembly with a YIELD or STOP sign on a separate sign support. In addition these figures show the 2-inch white vertical retroreflective strip that is required to be used on the front and back of the sign post with the Crossbuck sign, unless the roadway is one-way, in which case the strip on the back of the assembly can be omitted. A similar red vertical retroreflective strip can be mounted beneath a Stop or Yield sign if the sign is mounted on a separate post.

FIGURE 3: Crossbuck Assembly with a YIELD or STOP Sign on the Crossbuck Sign Support



* Height may be varied as required by local conditions and may be increased to accommodate signs mounted below the Crossbuck sign

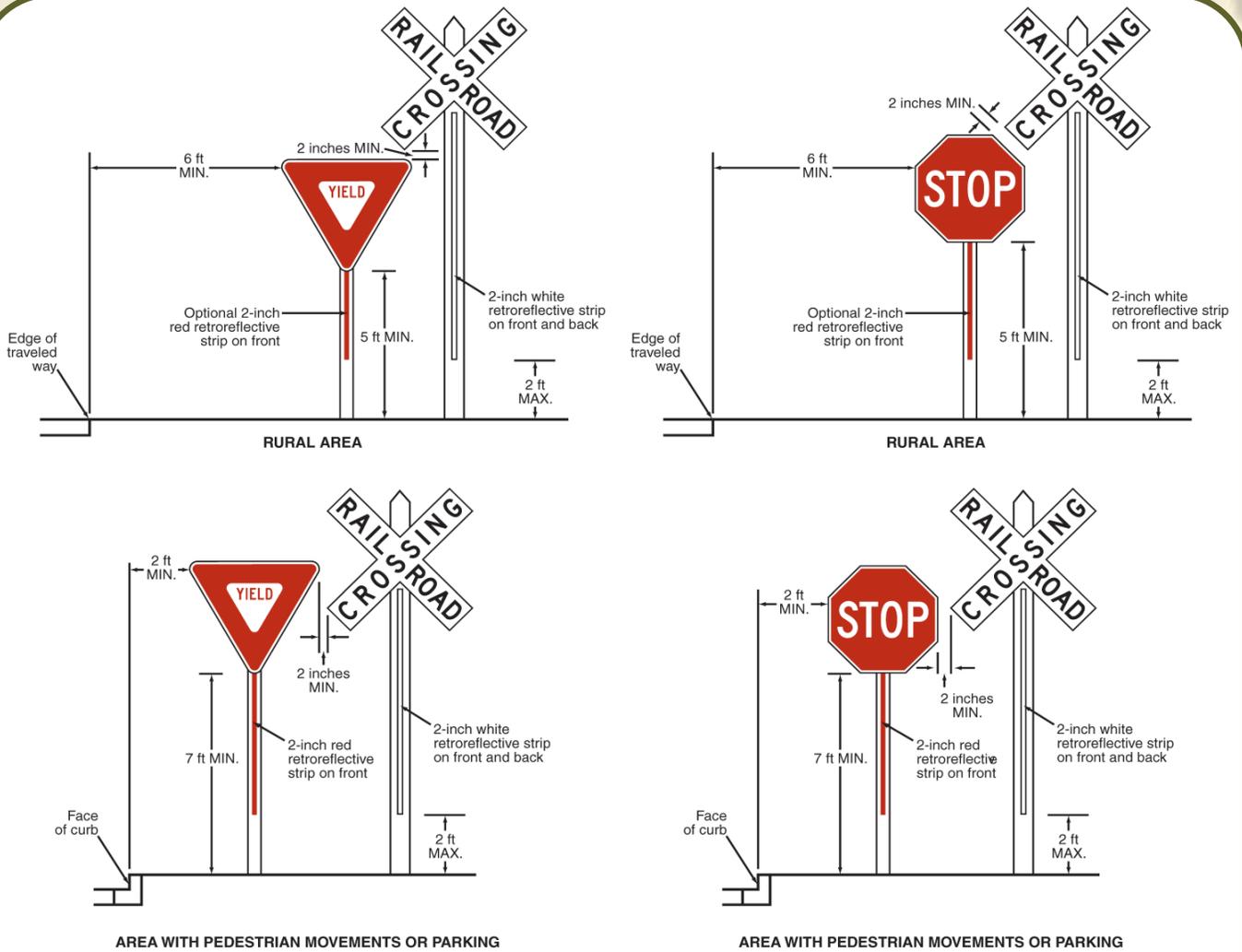
** Measured to the ground level at the base of the support

Notes:

1. YIELD or STOP signs are used only at passive crossings. A STOP sign is used only if an engineering study determines that it is appropriate for that particular approach.
2. Mounting height shall be at least 4 feet for installations of YIELD or STOP signs on existing Crossbuck sign supports.
3. Mounting height shall be at least 7 feet for new installations in areas with pedestrian movements or parking.

Source: MUTCD Figure 8B-2

FIGURE 4: Crossbuck Assembly with a YIELD or STOP Sign or a Separate Sign Support



Notes:

1. YIELD signs are used only at passive crossings.
2. STOP signs are used only at passive crossings and only if an engineering study determines that it is appropriate for that particular approach.
3. Place the face of the signs in the same plane and place the YIELD or STOP sign closest to the traveled way. Provide a 2-inch minimum separation between the edge of the Crossbuck sign and the edge of the YIELD or STOP sign.

Source: MUTCD, Figure 8B-3

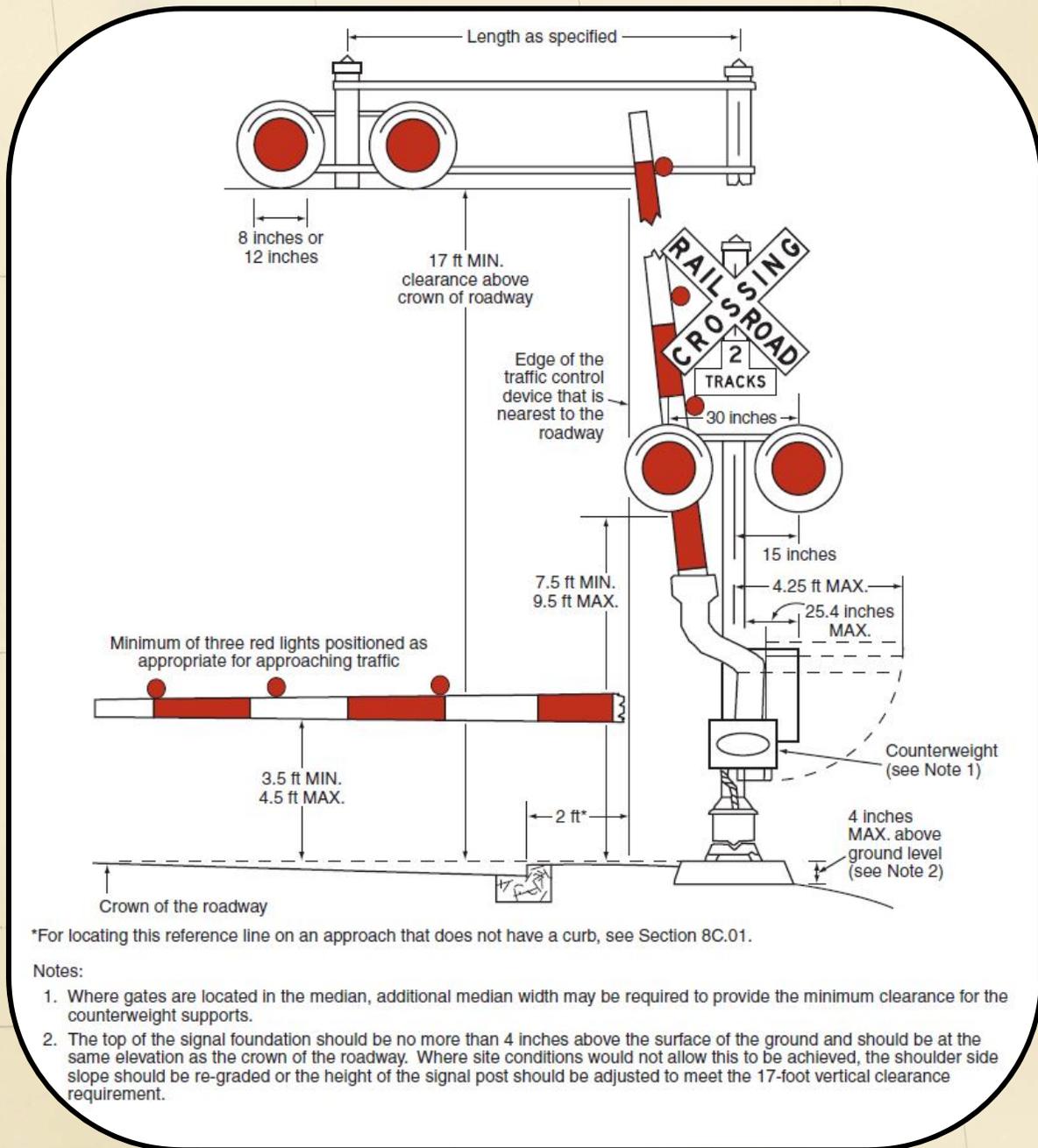
An exception to the requirement that passive grade crossings be equipped with a Crossbuck assembly with either a YIELD or STOP sign is if road users are directed by an authorized person on the ground to not enter the crossing at all times that an approaching train is about to occupy the crossing.

Active Grade Crossings

Active traffic control systems inform road users of the approach or presence of rail traffic at grade crossings. These systems include four-quadrant gate systems, automatic gates, flashing light signals, traffic control signals, actuated blank-out and variable message signs, and other active traffic control devices. The devices employed in active traffic control systems shall be actuated by some form of rail traffic detection.

As illustrated in figure 5, post-mounted and overhead flashing-light signals may be used separately or in combination with each other as determined by an engineering study. Flashing lights may be used without automatic gate assemblies as determined by an engineering study.

FIGURE 5: Composite Drawing of Active Traffic Control Devices for Grade Crossings Showing Clearances



When indicating the approach or presence of rail traffic, the flashing-light signal shall display toward approaching highway traffic two red lights mounted in a horizontal line flashing alternately. If used, flashing-light signals shall be placed to the right of approaching highway traffic on all highway approaches to a grade crossing. They shall be located laterally with respect to the highway in compliance with the figure above except where such location would adversely affect signal visibility.

If used at a grade crossing with highway traffic in both directions, back-to-back pairs of lights shall be placed on each side of the tracks. On multi-lane one-way streets and divided highways, flashing-light signals shall be placed on the approach side of the grade crossing on both sides of the roadway or shall be placed above the highway as shown in figure 5. Flashing-light signals may be installed on overhead structures or cantilevered supports where needed for additional emphasis or for better visibility to approaching traffic, particularly on highways with profile restrictions or on multi-lane approaches. When used, breakaway or frangible bases shall not be used for overhead structures or cantilevered supports.

Each red signal unit in the flashing-light signal shall flash alternately. The number of flashes per minute for each lamp shall be 35 minimum and 65 maximum. Each lamp shall be illuminated approximately the same length of time. Total time of illumination of each pair of lamps shall be the entire operating time. Flashing-light units shall use either 8-inch or 12-inch nominal diameter lenses, determined similarly as traffic signal indications.

Flashing-light signals shall operate for at least 20 seconds before the arrival of any rail traffic, except on tracks where a rail traffic operates at less than 20 mph and where road users are directed by an authorized person on the ground to not enter the crossing at all times that approaching rail traffic is about to occupy the crossing, a shorter signal operating time for the flashing-light signals may be used.

An automatic gate is a traffic control device used in conjunction with flashing-light signals. The automatic gate as shown in the figure above shall consist of a drive mechanism and a fully retroreflectorized red and white-striped gate arm with lights. When in the down position, the gate arm shall extend across the approaching lanes of highway traffic.

In the normal sequence of operation, unless constant warning time detection or other advanced system requires otherwise, the flashing-light signals and the lights on the gate arm in its normal upright position shall be activated immediately upon detection of approaching rail traffic. The gate arm shall start its downward motion not less than 3 seconds after the flashing-light signals start to operate, shall reach its horizontal position at least 5 seconds before the arrival of the rail traffic, and shall remain in the down position as long as the rail traffic occupies the grade crossing.

When the rail traffic clears the grade crossing, and if no other rail traffic is detected, the gate arm shall ascend to its upright position, following which the flashing-light signals and the lights on the gate arm shall cease operation.

Gate arms shall be fully retroreflectorized on both sides and shall have vertical stripes alternately red and white at 16-inch intervals measured horizontally.

Gate arms shall have at least three red lights. When activated, the gate arm light nearest the tip shall be illuminated continuously and the other lights shall flash alternately in unison with the flashing-light signals. The entrance gate arm mechanism shall be designed to fail safe in the down position.

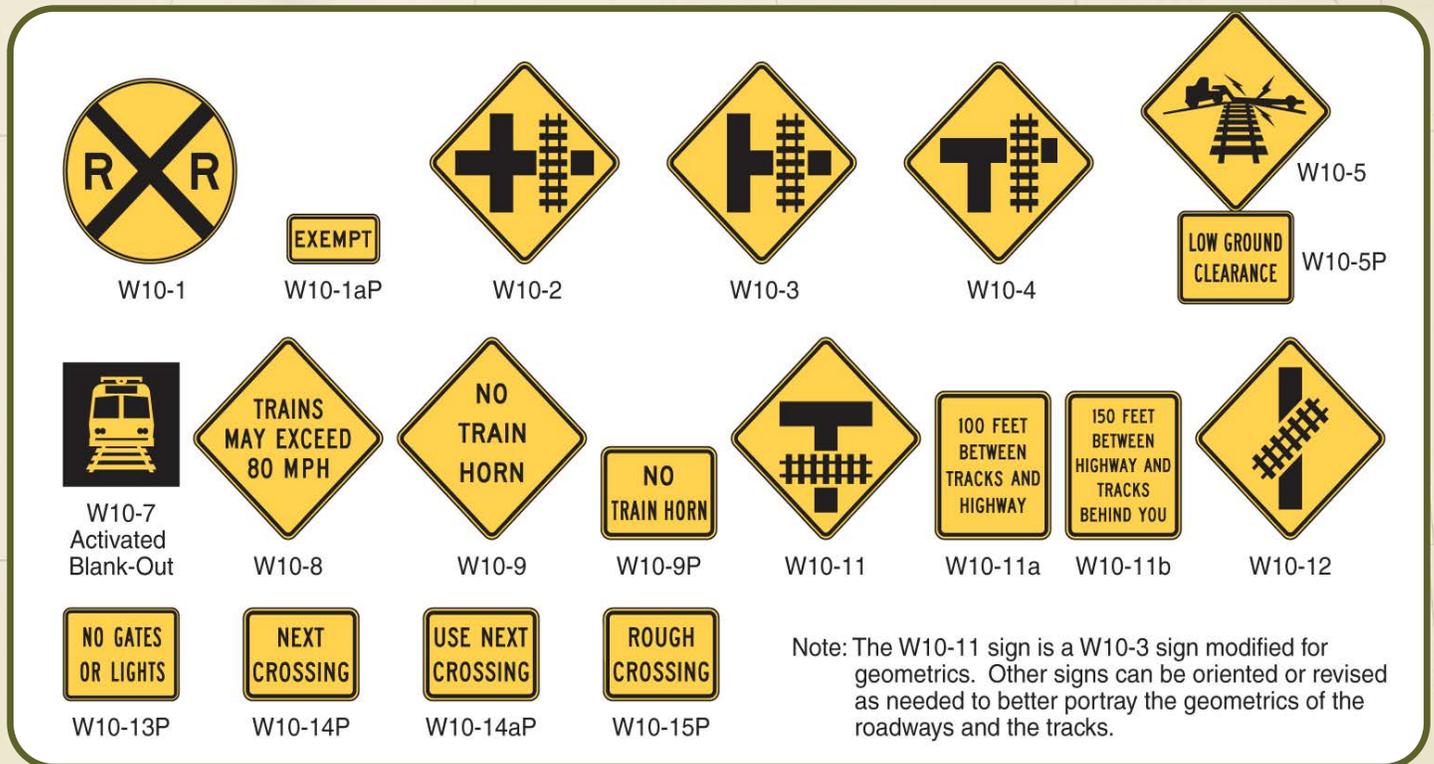
Grade Crossing Advance Warning Signs

A Highway-Rail Grade Crossing Advance Warning (W10-1) sign, the first sign shown in figure 6, shall be used on each highway in advance of every highway-rail grade crossing in semi-exclusive alignments, except in the following circumstances:

- On an approach to a grade crossing from a T-intersection with a parallel highway if the distance from the edge of the track to the edge of the parallel roadway is less than 100 feet and W10-3 signs are used on both approaches of the parallel highway.
- On low-volume, low-speed highways crossing minor spurs or other tracks that are infrequently used and road users are directed by an authorized person on the ground to not enter the crossing at all times that approaching rail traffic is about to occupy the crossing.

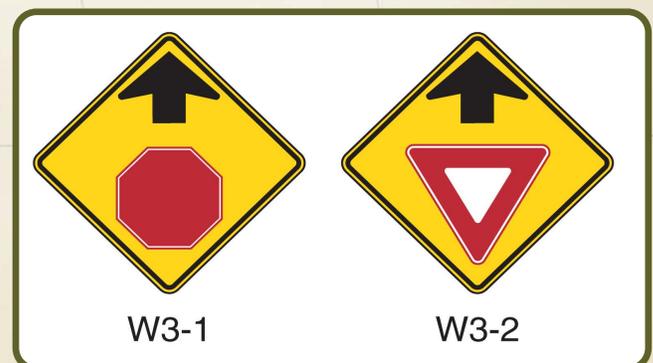
- In business or commercial areas where active grade crossing traffic control devices are in use.
- Where physical conditions do not permit even a partially effective display of the sign.

FIGURE 6: Warning Signs and Plaques for Grade Crossings



A Yield Ahead (W3-2) or Stop Ahead (W3-1) Advance Warning sign shall also be installed if the visibility of the Crossbuck assembly is restricted by roadway geometry or obstructions. If a Yield Ahead or Stop Ahead sign is installed on the approach to the crossing, the e Highway-Railroad Grade Crossing Advance Warning (W10-1) sign shall be installed upstream from the Yield Ahead or Stop Ahead sign.

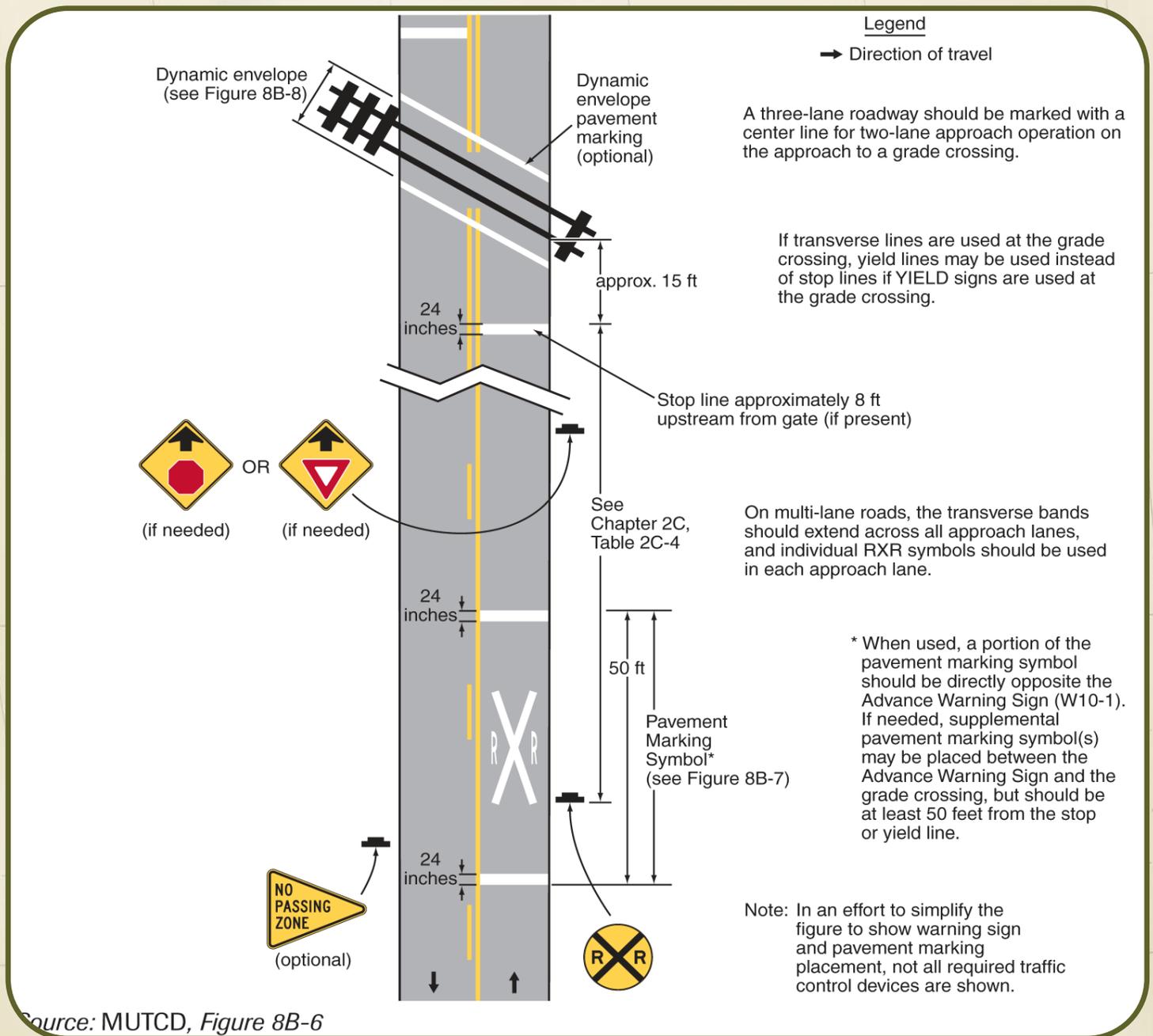
If the distance between the tracks and a parallel highway, from the edge of the tracks to the edge of the parallel roadway, is less than 100 feet, W10-2, W10-3, or W10-4 signs (see figure 6) shall be installed on each approach of the parallel highway to warn road users making a turn that they will encounter a grade crossing soon after making a turn, and a W10-1 sign for the approach to the tracks shall not be required to be between the tracks and the parallel highway. If the W10-2, W10-3, or W10-4 signs are used, sign placement in accordance with the guidelines for Intersection Warning signs in MUTCD Table 2C-4 using the speed of through traffic shall be measured from the highway intersection.



Pavement Markings for Grade Crossings

All grade crossing pavement markings shall be retroreflective white excluding centerline pavement markings. On paved roadways, pavement markings in advance of a grade crossing shall consist of an "X", the letters "RR", a no-passing zone marking, and certain transverse lines as shown in figure 7. Identical markings shall be placed in each approach lane on all paved approaches to grade crossings where the posted or statutory highway speed limit is 40 mph or greater. Pavement markings shall not be required at grade crossings where the posted or statutory highway speed limit is less than 40 mph if an engineering study indicates that other installed devices provide suitable warning and control. Pavement markings shall not be required at grade crossings in urban areas if an engineering study indicates that other installed devices provide suitable warning and control.

FIGURE 7: Example of Placement of Warning Signs and Pavement Markings at Grade Crossing



Source: MUTCD, Figure 8B-6

Traffic Signals near Grade Crossings

The MUTCD has a traffic signal warrant for a roadway intersection near a grade crossing. This warrant is intended for use at an intersection that would otherwise not meet signal warrants where the proximity to the intersection of a grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal. This warrant requires a maximum distance of 140 feet between the center of the track and the Stop or Yield line of the intersection, and that certain traffic volume levels are met for both the major and minor approaches, while considering the distance between the intersection and the crossing as presented in the MUTCD.

If this warrant is used for signalization of an intersection, then the traffic signal must have actuation for the minor street, the signal must operate with train preemption, and the grade crossing must have flashing lights. It should also have gates.

If a grade crossing is equipped with a flashing-light signals, and is located within 200 feet of a signalized intersection, the traffic signal should be equipped with train preemption. Coordination with the flashing-light signals, queue detection, or other alternatives should be considered for traffic control signals located farther than 200 feet from the highway-rail grade crossing. Factors to be considered should include traffic volumes, highway vehicle mix, highway vehicle and train approach speeds, frequency of trains, and queue lengths.

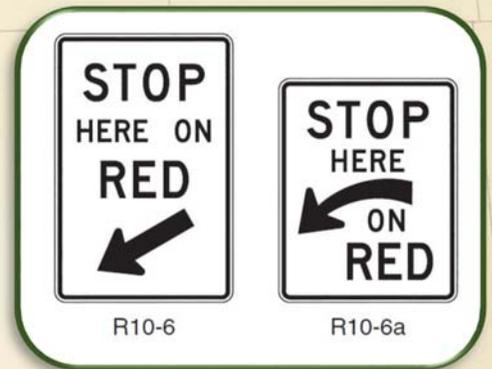
If a highway-rail grade crossing is located within 50 feet (or within 75 feet for a highway that is regularly used by multi-unit highway vehicles) of a signalized intersection, the use of pre-signals to control traffic approaching the grade crossing should be considered. If used, the pre-signals shall display a steady red signal indication during the track clearance portion of a signal preemption sequence to prohibit additional highway vehicles from crossing the railroad track. Visibility-limited signal faces should be used at the intersection for the downstream signal faces that control the approach that is equipped with pre-signals.

The pre-signal phase sequencing may be timed with an offset from the downstream signalized intersection such that the railroad track area and the area between the railroad track and the downstream signalized intersection is generally kept clear of stopped vehicles.

If a pre-signal is installed in this manner, a STOP HERE ON RED (R10-6) sign shall be installed at the Stop line. If there is a nearby signalized intersection with insufficient clear storage distance for a design vehicle, or the highway-rail grade crossing does not have gates, a No Turn on Red (R10-11, R10-11a, or R10-11b) sign shall be installed for the approach that crosses the railroad track.

At locations where a highway-rail grade crossing is located more than 50 feet (or more than 75 feet for a highway regularly used by multi-unit highway vehicles) from an intersection controlled by a traffic control signal, a pre-signal may be used if an engineering study determines a need.

The agency responsible for operation of the signal should determine the preemption operation and the timing of traffic signals interconnected with grade crossing. It is common for the railroad to be equipped with a detection system for an approaching train. The system will send an indication to the traffic signal that the train is approaching, and the preemption sequence would start. Signal phases conflicting with the train should have sufficient time to clear the roadway and intersection. Pedestrian signals should have sufficient time to clear with the regularly timed DON'T WALK interval. At larger intersections, the pedestrian phases may govern the amount of time needed from the railroad detection system. The signal should allow the roadway approach conflicting with the railroad to clear between the crossing and the intersection without letting additional traffic to enter the intersection. The signal can then either go into a phase that does not conflict with the train, or go into a flash mode until the train clears the crossing.

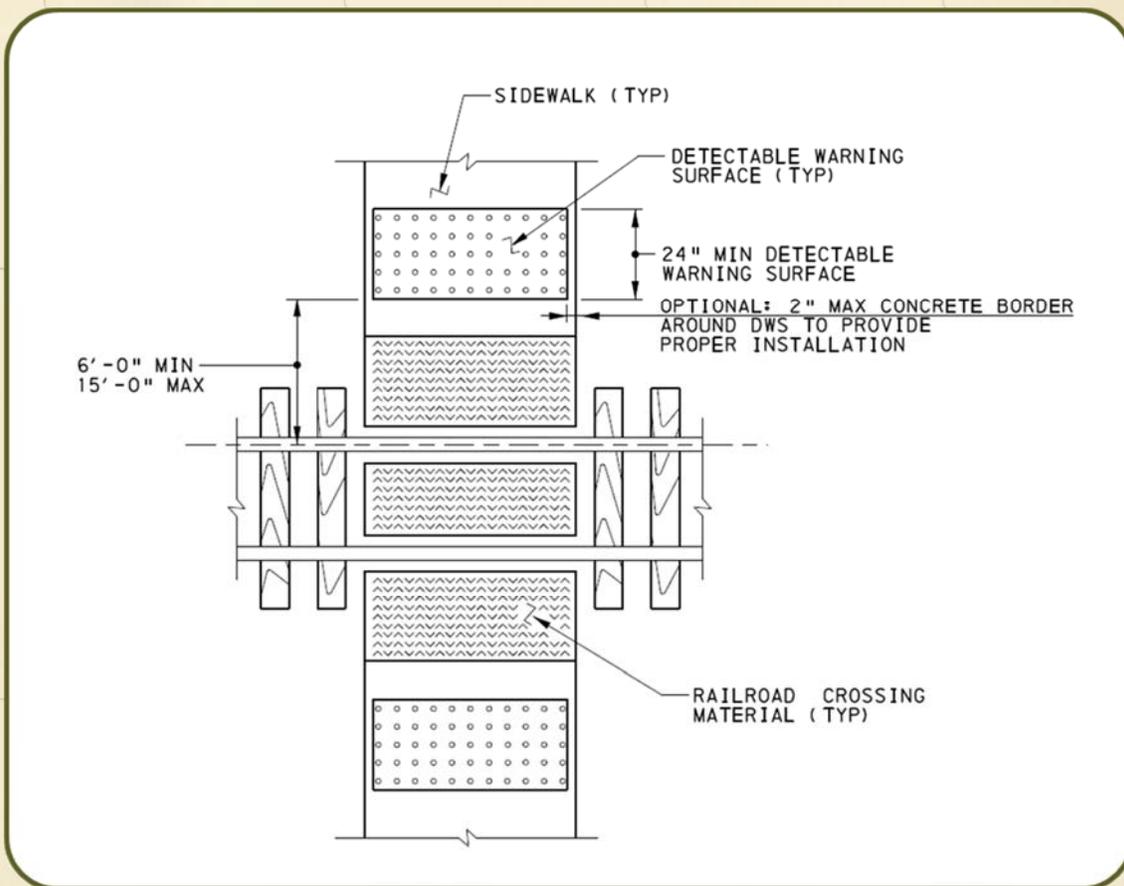


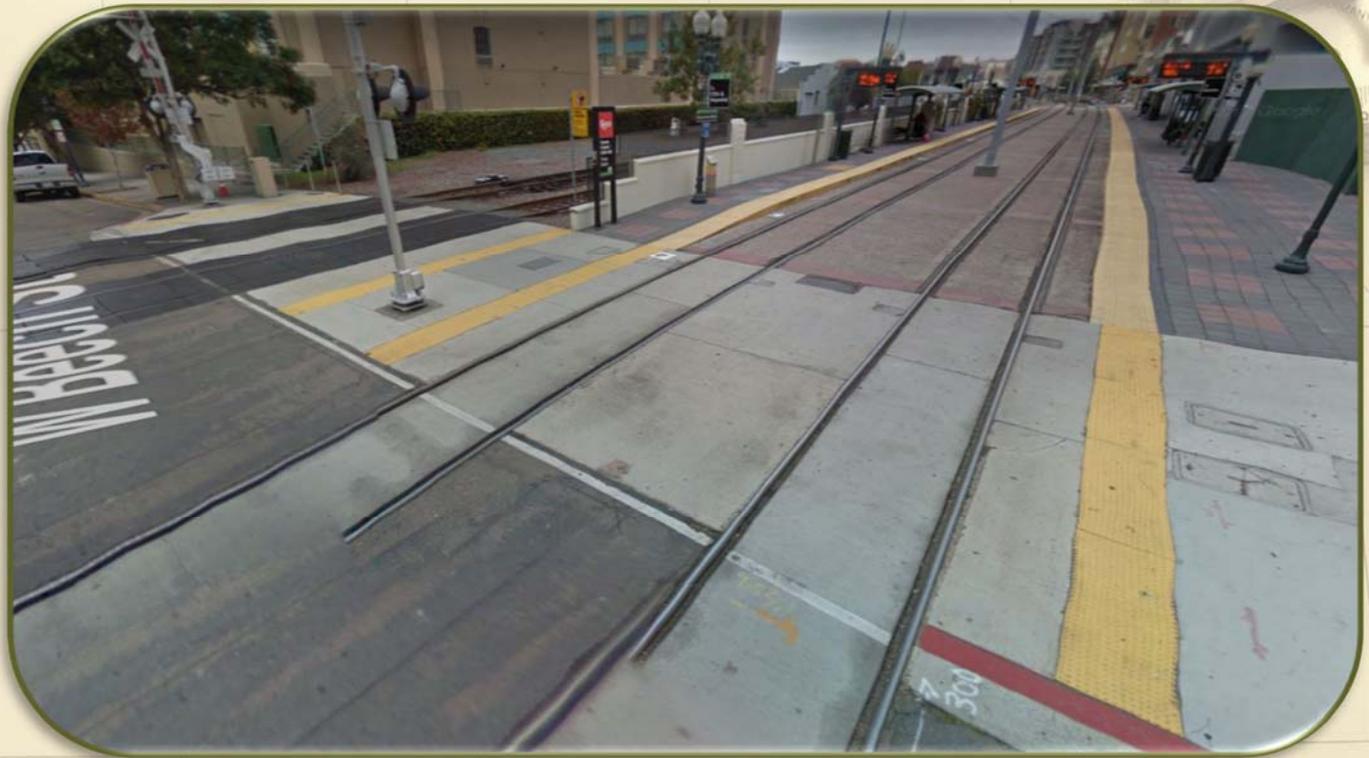
It is recommended that traffic signals adjacent to grade crossings and that are coordinated with the flashing-light signals or that include railroad preemption features be provided with a back-up power supply.

Grade Crossings at Pedestrian Facilities

The Architectural Barriers Act, with which Federal installations must comply, requires detectable warning surfaces (DWS) at grade crossings, similar to their use at intersection curb ramps. The DWS shall be located so that the edge nearest the rail crossing is 6 feet minimum and 15 feet maximum from the centerline of the nearest rail. The rows of truncated domes in a detectable warning surface shall be aligned to be parallel with the direction of wheelchair travel. This is illustrated in figure 8 and shown in the image below.

FIGURE 8: Detectable Warning Surface Use at Grade Crossings at Pedestrian Facilities





The MUTCD identifies considerations for the use of crossbucks, flashing lights, and gates for pedestrian crossings. The appropriateness of these features depends on site-specific conditions. While these are generally not required, there may be cases where any of the following may be appropriate:

- Crossbuck sign with flashing-light signals exclusively for pedestrian crossings (figure 9)
- Crossbuck sign with flashing-light signals and shared pedestrian/roadway gate (figure 10)
- Separate Crossbuck sign, flashing lights and gate (figure 11).



FIGURE 9: Example of Flashing-Light Signal Assembly for Pedestrian Crossings

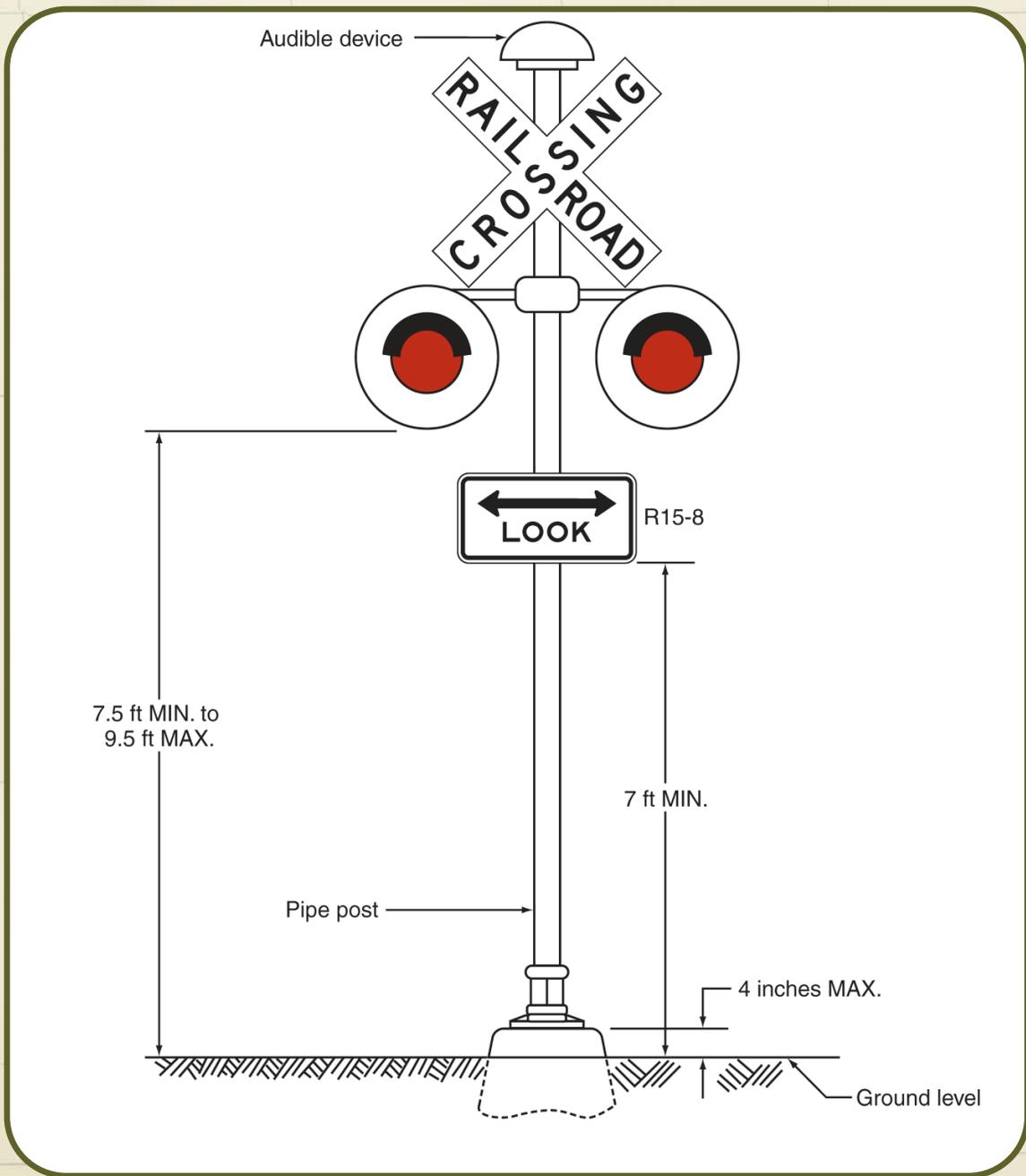


FIGURE 10: Example of a Shared Pedestrian/Roadway Gate

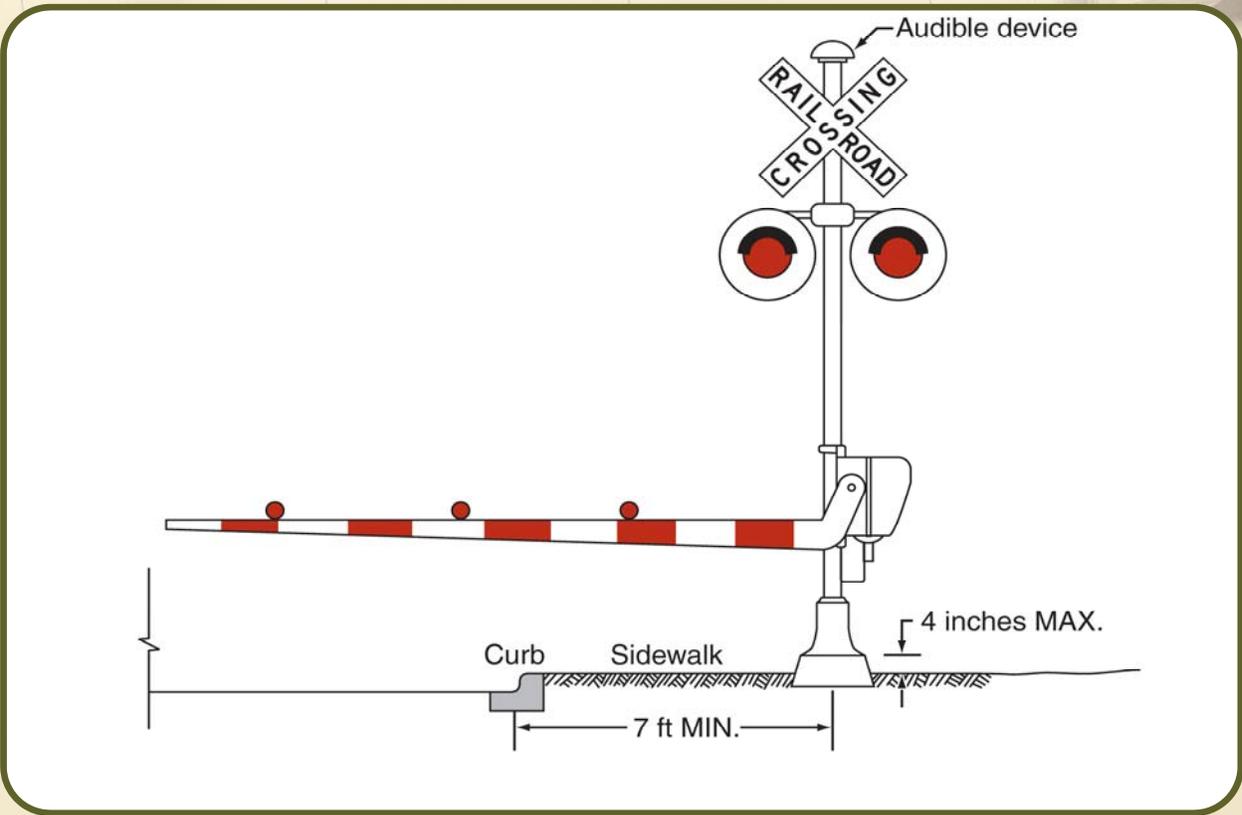


FIGURE 11: Example of a Separate Pedestrian Gate

The Traffic Engineering Team at SDDCTEA is available for assistance and for conducting an engineering study for STOP-control at a passive grade crossing.

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