Transport Canada Transports Canada

GRADE CROSSINGS STANDARDS

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Canada

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PART A – INTRODUCTION

1 CITATIONS

The following are the citations for documents referred to in the Standards:

"***62-GP-11M***" means the *Standard for : Marking Material, Retroreflective Elements, Adhesive Backing*, 62-GP-11M, published by the Canadian Government Specifications Board (CGSB), dated May 1978 - as amended in July 1987 (Amendment No 1);

*"**AREMA Communications and Signals Manual**"* is the *Communications and Signals Manual of Recommended Practice*, published by the Communications and Signals Group of the American Railway Engineering and Maintenance of Way Association, as amended from time to time;

"***ASTM D4956***" is the 11th edition of the *Standard Specification for Retroreflective Sheeting for Traffic Control,* published by the American Society for Testing and Materials, dated March 30, 2011;

*"**GCS**"* means the *Grade Crossings Standards*;

*"**Manual of Uniform Traffic Control Devices for Canada**"* is the 4th edition of the *Manual of Uniform Traffic Control Devices for Canada*, prepared by the Traffic Operations and Management Standing Committee, published by the Transportation Association of Canada, dated September 1998.

2 INTERPRETATION

The following definitions apply in this Standard:

*"**crossing user**"* means drivers of vehicles, pedestrians, cyclists and persons using assistive devices;

*"**cross-product**"* means the product of the average annual daily railway movements and the average annual daily traffic of vehicles on the road that pass across the grade crossing;

*"**travelled way**"* means that part of a road intended for vehicular use, excluding shoulders.

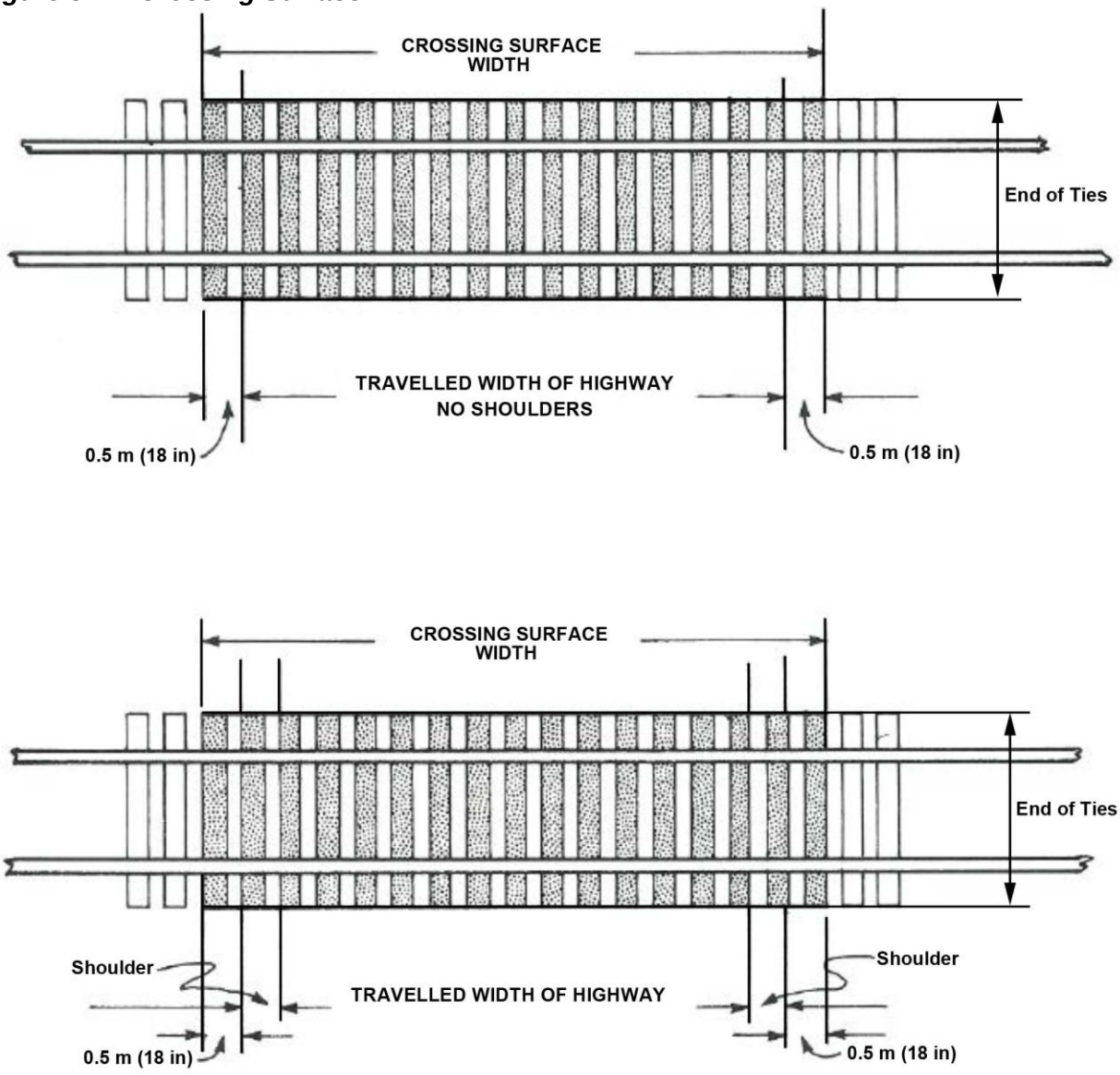
PART B - EXISTING CROSSINGS

3 GRADE CROSSING SURFACE

3.1 The crossing surface must be of a width that is equal to the width of the travelled way and shoulders, plus 0.5 m on each side, measured at right angles to the centreline of the road, as shown in Figure 3-1.

3.2 A flangeway must be provided between the gauge side of the rail and the road surface and must be between 65 mm and 120 mm wide, and between 50 mm and 75 mm deep.

Figure 3-1 – Crossing Surface



4 RAILWAY CROSSING SIGNS AND NUMBER OF TRACKS SIGNS

4.1 Railway crossing sign must have a 50 mm border of transparent red ink that is silk-screen processed over sheeting material. A number of tracks sign digit and symbol must be transparent red ink that is silk-screened processed; however an existing digit and symbol may be black until time of replacement.

4.1.1 Without Warning Systems

(a) A reflectorized railway crossing sign must be as shown in Figure 4-1(a).

(b) Railway crossing signs must be located as shown in Figure 4-2 and clearly visible to all persons approaching the grade crossing on the grade crossing road approach or intersecting road approaches.

(c) Signs must be located between 0.3 m and 2.0 m from the face of curb, or outer edge of road approach shoulder; or, where there is no curb or shoulder, 2.0 m to 4.5 m from the edge of the travelled way.

(d) Railway crossing signs must be located as close as possible to the nearest rail but no closer than 3.0 m.

(e) Where there is more than one track at a grade crossing, an additional sign indicating the number of tracks to be crossed, as shown in Figure 4-1(b), must be installed on the supporting post of each railway crossing sign.

(f) If a road approach crosses adjacent tracks and the minimum distance between track centre lines, measured along the travelled surface parallel to the axis of the road approach, is more than 30 m, each track or set of tracks so separated must have separate railway crossing signs.

(g) A sidewalk, path or trail with its centreline more than 3.6 m (12 ft.) from a railway crossing sign supporting post beside a road approach for vehicle traffic must have separate railway crossing signs.

4.1.2 Railway Crossing Signs – With Warning Systems

(a) A reflectorized railway crossing sign as shown in Figure 4-1(a) must be installed as shown in Figures 4-3 and 4-4.

(b) Where there is more than one track at a grade crossing, an additional sign indicating the number of tracks to be crossed, as shown in Figure 4-1(b), must be installed on the supporting post of each railway crossing sign.

4.1.3 Reflective Marking Material Specifications

(a) The reflective marking material of the signs referred to in 4.1.1 and 4.1.2 must cover the entire surface of the signs.

(b) The reflective marking material must meet the Level 2 reflective intensity values in Table 2 of the 62-GP-11M standard (cited in Part A).

(c) The reflective marking material of the sign shall be maintained in a manner to preserve at least 50% of the Level 2 reflective intensity values in Table 2 of the 62-GP-11M standard (cited in Part A).

Figure 4-1 – Railway Crossing Sign and Number of Tracks Sign

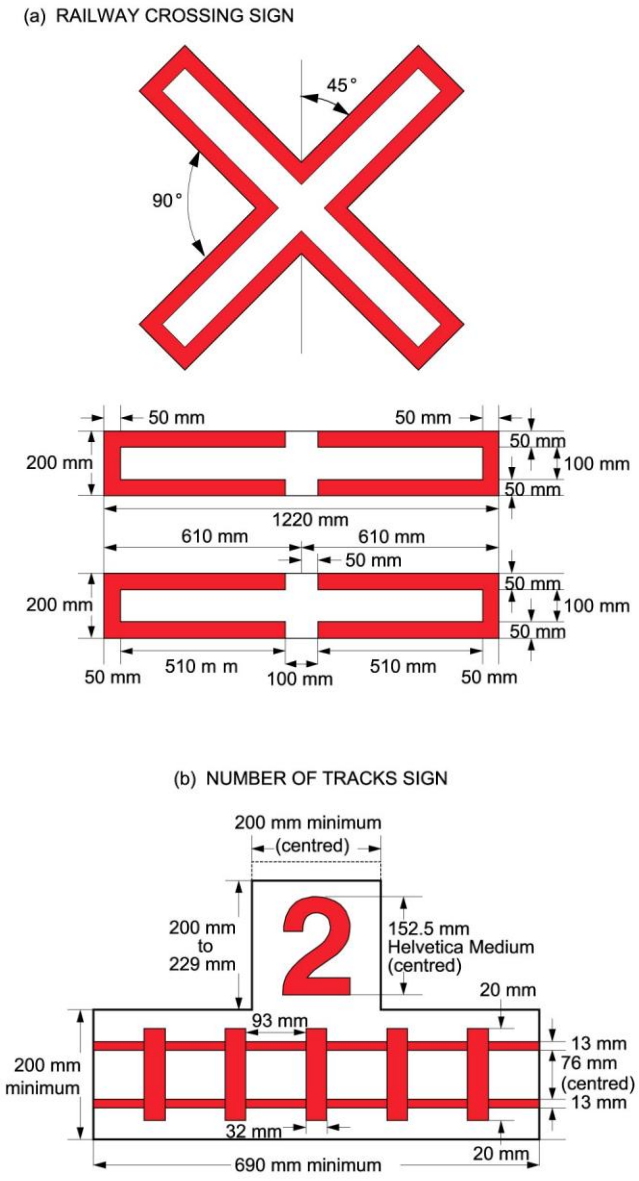


Figure 4-2 – Location of Railway Crossing Signs and Number of Tracks Signs (public grade crossings without warning systems)

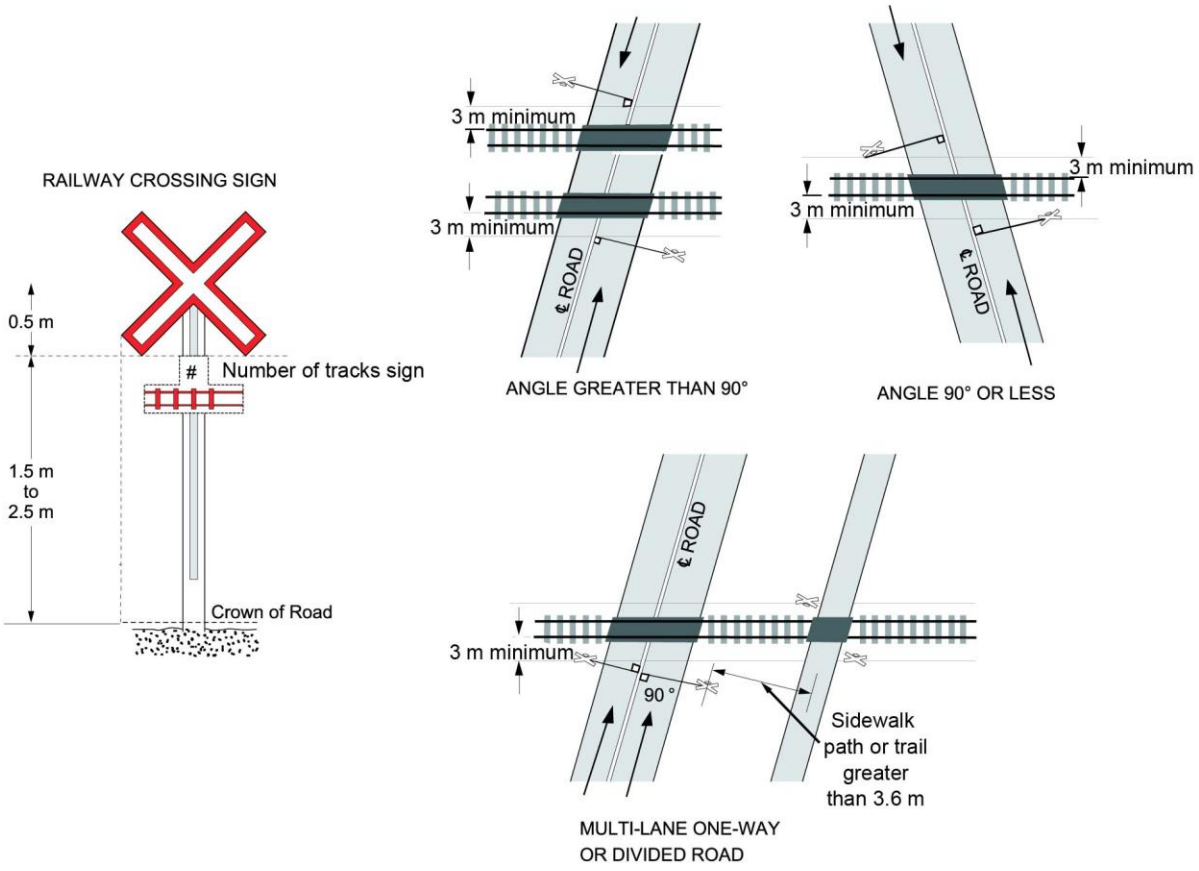


Figure 4-3 – Grade Crossing Warning Signal of Flashing Light Type

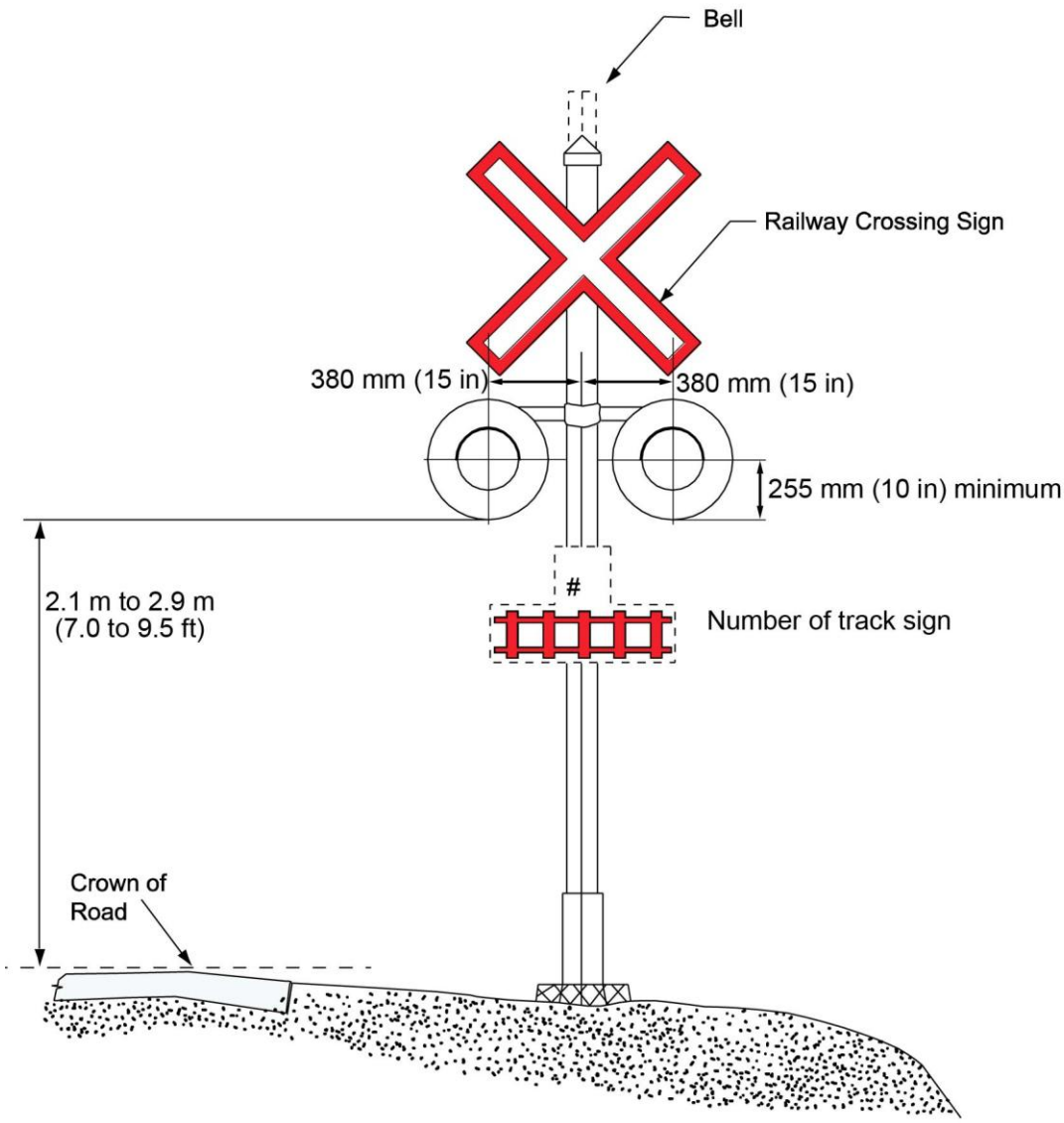
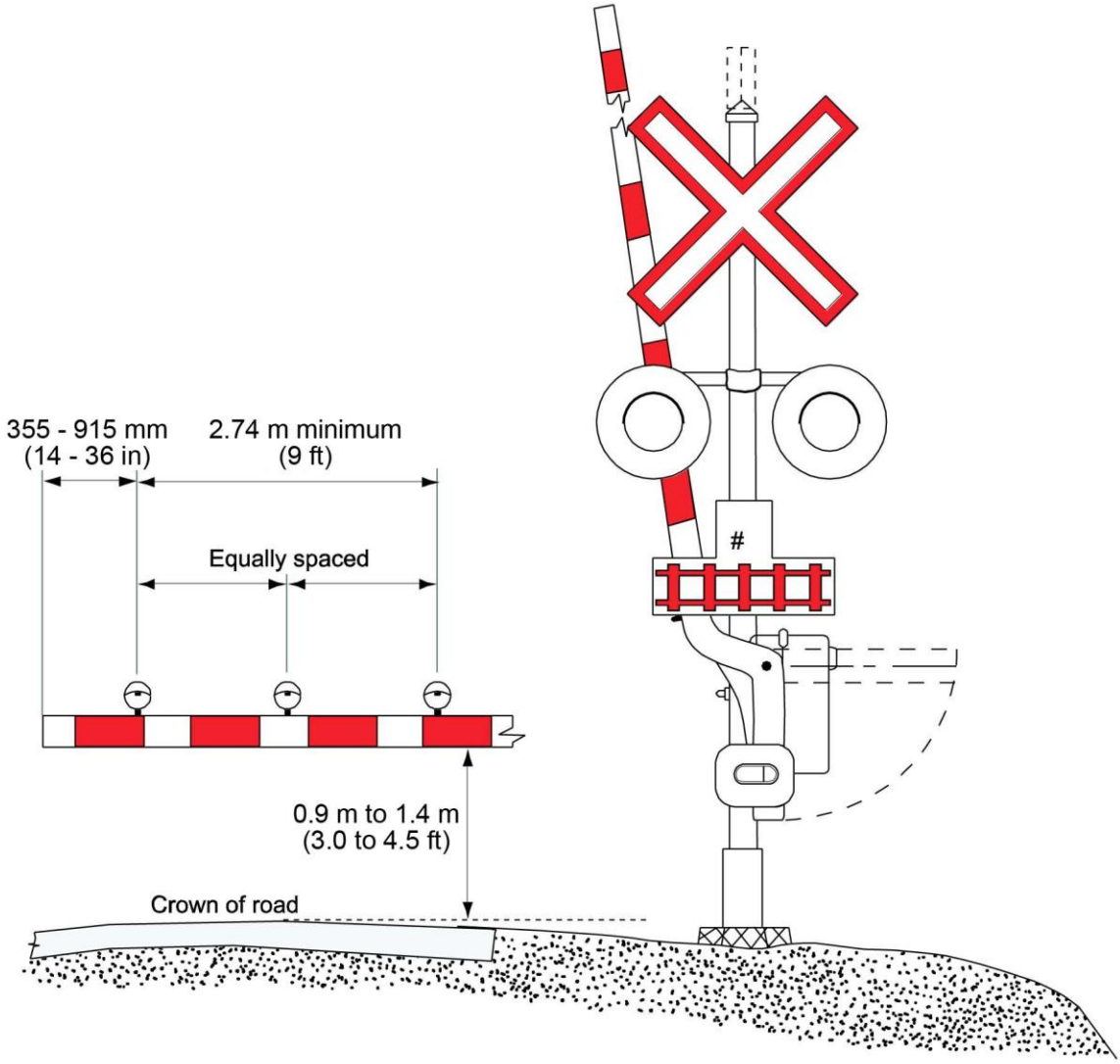


Figure 4-4 – Gates at Grade Crossings

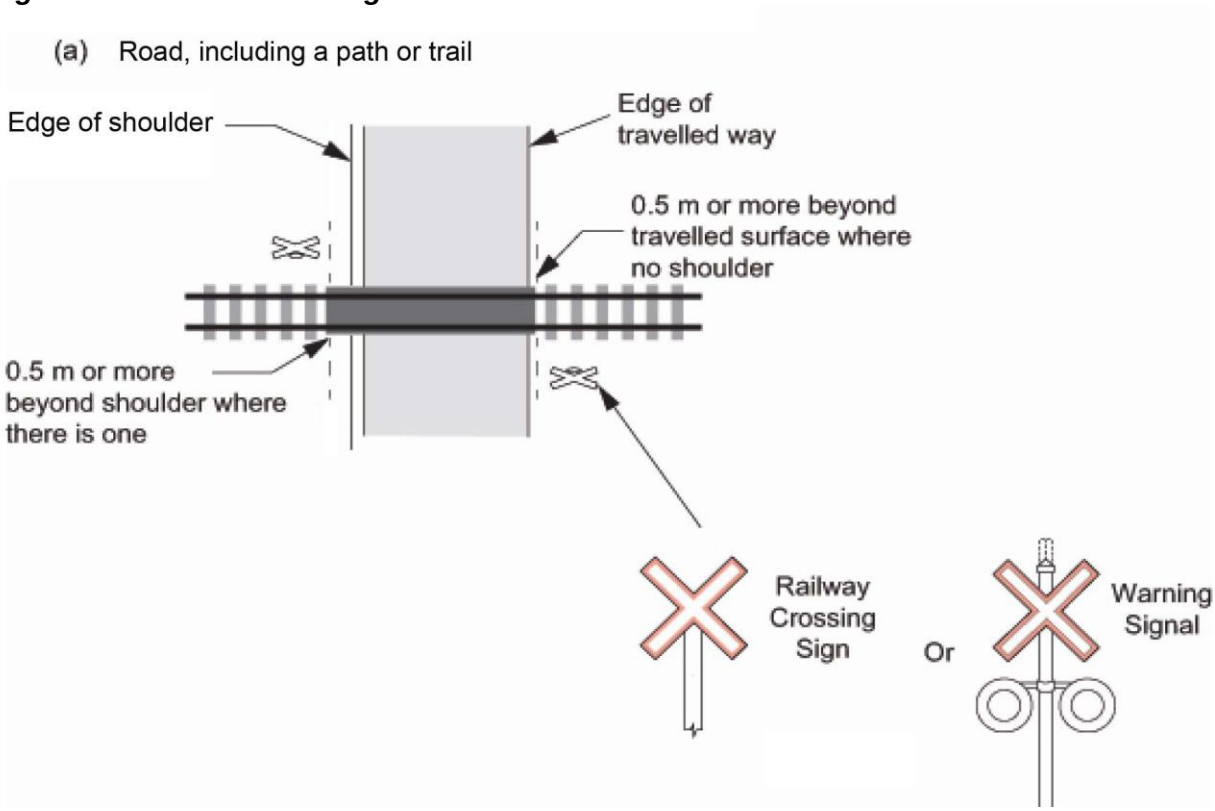


PART C - NEW STANDARDS

5 GRADE CROSSING SURFACE

5.1 Crossing surfaces of grade crossings, and a crossing surface of a sidewalk, path or trail must be as shown in Figure 5-1 and Table 5-1, and they must be smooth and continuous.

Figure 5-1 – Grade Crossing Surface Dimensions



(b) Sidewalk, path, or trail along a road

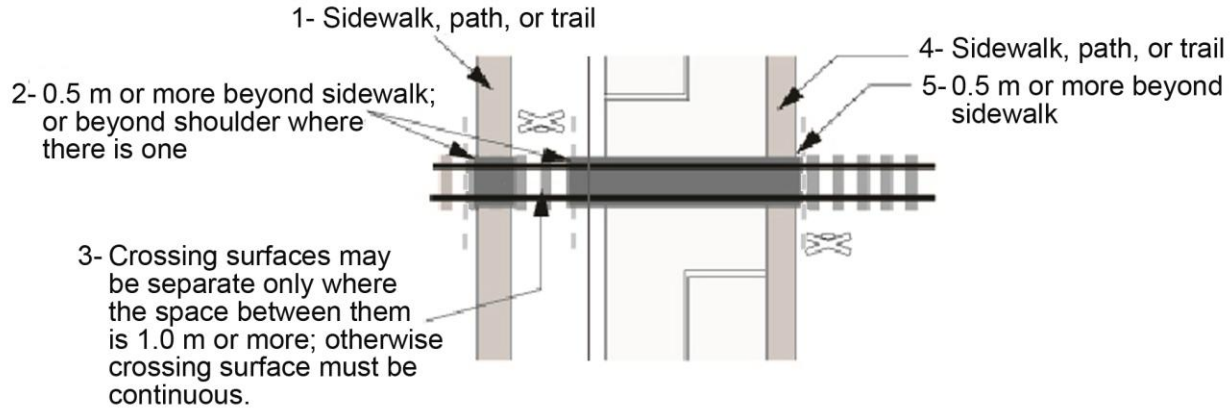


Table 5-1 – Grade Crossing Surface – Cross Section

a) Flangeway gap:		
Width	**Minimum**	65 mm
	Maximum for:	
	Public sidewalks, paths or trails designated by the road authority for use by persons using assistive devices	75 mm
	All other grade crossings	100 mm
Depth:	**Minimum**	50 mm
	Maximum for:	
	Public sidewalks, paths and trails designated by the road authority for use by cyclists or persons using assistive devices	75 mm
	All other grade crossings	None
(b) Field side gap A space is permitted on the outer side of the rail at rural locations, except for public sidewalks, paths or trails designated by the road authority as regularly used by cyclists or persons using assistive devices.		
	Maximum width	100 mm
	Maximum depth	None
(c) Elevation of top of rail with respect to the crossing surface The top of the crossing surface for grade crossings must be installed as close as possible to the top of rail within the wear limits below:		
Wear limits:		
Any public sidewalk, path or trail for regular use by persons using assistive devices		
	Maximum distance above crossing surface	13 mm
	Minimum distance below crossing surface	7 mm
All other public grade crossings		± 25 mm
Private grade crossings		± 50 mm

6 ROAD GEOMETRY (GRADE CROSSINGS AND ROAD APPROACHES)

6.1 The horizontal and vertical alignment of the road approach and the grade crossing surface must be smooth and continuous within the stopping sight distance.

6.2 The allowable difference between the road approach gradient and railway cross-slope, or the railway gradient and the road approach cross-slope, must be in accordance with the design standards (Table 2.3.13.1) of the *Geometric Design Guide*.

6.3 The maximum gradients for road approaches to a grade crossing must not exceed the following:

(a) ratio of 1:50 (2 per cent) within 8 m of the nearest rail and 1:20 (5 per cent) for 10 m beyond, at public grade crossings for vehicular use;

(b) ratio of 1:50 (2 per cent) within 8 m of the nearest rail and 1:10 (10 per cent) for 10 m beyond, at private grade crossings for vehicular use;

(c) ratio of 1:50 (2 per cent) within 5 m of the nearest rail at grade crossings for pedestrian or cyclist use only; and

(d) ratio of 1:100 (1 per cent) within 5 m of the nearest rail at grade crossings specifically identified as a route for persons using assistive devices.

6.4 The width of the travelled way and shoulders at the grade crossing surface must not be less than the width of the travelled way and shoulders on the road approaches.

6.5 A grade crossing where the railway design speed is more than 25 km/h (15 mph) must be constructed with a crossing angle at the crossing surface of:

(a) not less than 70 nor greater than 110 degrees without a warning system, using the tangent of the road approach along the centreline to the tangent of the line of railway along the centreline; or

(b) not less than 30 nor greater than 150 degrees with a warning system using the tangent of the road approach along the centreline to the tangent of the line of railway along the centreline.

7 SIGHTLINES

7.1.1 Sightlines are measured from a point 1.05 m above the road approach to a point 1.2 m above top of lowest rail.

7.1.2 For the purposes of article 24(1) (b) of the GCR, Class of Track refers to the Table below:

Column 1	***Column 2***	***Column 3***
Class of Track	***The maximum allowable operating speed for freight trains is -***	***The maximum allowable operating speed for passenger trains is -***
Class 1 track	17 km/h (10 mph)	25 km/h (15 mph)
Class 2 track	41 km/h (25 mph)	49 km/h (30 mph)
Class 3 track	65 km/h (40 mph)	97 km/h (60 mph)
Class 4 track	97 km/h (60 mph)	129 km/h (80 mph)
Class 5 track	129 km/h (80 mph)	153 km/h (95 mph)

Source: Rules Respecting Track Safety (http://www.tc.gc.ca/eng/railsafety/rules-tce54-830.htm)

7.2 New equipment housings, new tool sheds or any other new building or structure, except for grade crossings with warning systems equipped with gates, must be located no closer than 9 m (30 ft.) from the travelled way of the road approach, and no closer than 8 m (26 ft.) from the nearest rail, and must not interfere with sightlines in 7.3 and 7.4.

7.3 Sightlines for grade crossings without a warning system

(a) Sightlines must be provided and maintained as shown in Figure 7-1, as the case may be.

7.4 Sightlines for grade crossings with a warning system without gates

(a) Sightlines on the railway right-of-way must be provided and maintained in accordance with Figure 7-1, as applicable, except that there is no clearing requirement beyond permanent visual barriers or beyond the visual limit of a curve.

7.5 Determination of sightlines

In Figure 7-1,

(a) SSD is the stopping sight distance calculated in accordance with article 1.2.5.2 of the *Geometric Design Guide*.

(b) D_{SSD} is the minimum distance along the line of railway that a driver must see approaching railway equipment from the stopping sight distance, and does not apply if the grade crossing is equipped with a Stop sign or warning system.

D_{SSD} is equal to the time required for the grade crossing design vehicle at its design speed to go from the stopping sight distance completely past the clearance point on the other side of the grade crossing.

$$D_{SSD} = V_T (2 + T_{SSD})/3.6 \text{ (m)}$$

$$D_{SSD} = 1.47V_T \times T_{SSD} \text{ (ft.)}$$

Where,

V_T = railway design speed in km/h (mph), and

T_{SSD} = [(SSD + cd + L)/0.278V].

Where,

V = road design speed (km/h)

cd = grade crossing clearance distance

L = length of the grade crossing design vehicle

(c) $D_{Stopped}$ is the minimum distance along the line of railway that a crossing user must be able to see approaching railway equipment from the stopped position at a grade crossing.

$D_{Stopped}$ is equal to the greater of the distances that railway equipment at the railway design speed will travel during

(i) the time that railway equipment operating at the railway design speed will travel during the Departure Time for the grade crossing design vehicle calculated in accordance with article 10.3.2, and

(ii) the Departure Time for pedestrians, cyclists, and persons using assistive devices calculated in accordance with article 10.3.3.

$D_{stopped}$ may be calculated by the following formula:

$$D_{stopped} = 1.47\ V_T \times T_{stopped}\ (ft.)$$

Where,

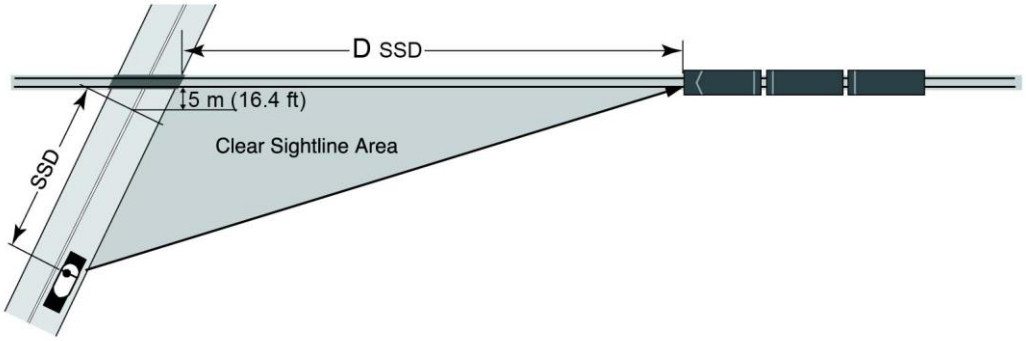
V_T = railway design speed in mph

$T_{stopped}$ = the Departure Times, calculated in accordance with article 10.3

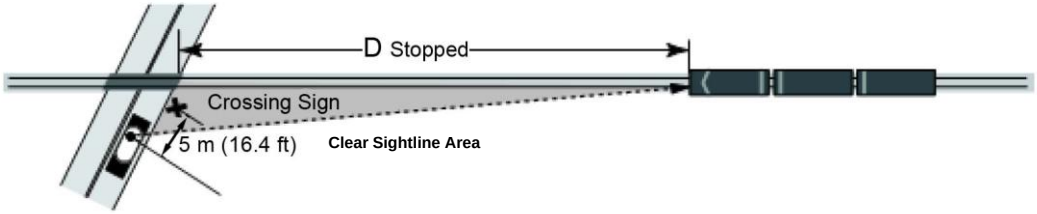
$D_{stopped}$ may be obtained directly from Table 7-1 using $T_{stopped}$ as applicable.

Figure 7-1 – Minimum Sightlines – Grade Crossings

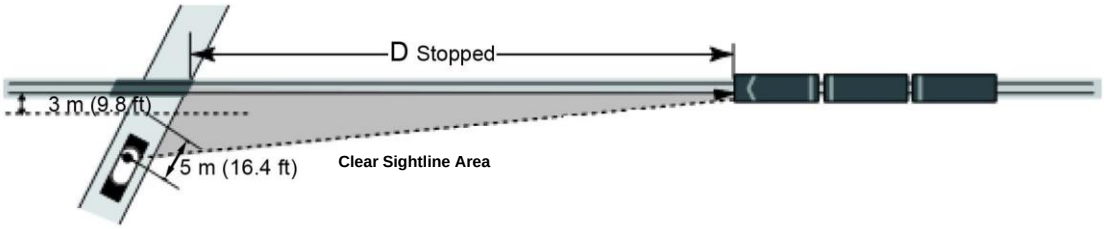
(a) Minimum Sightlines for Drivers Approaching a Grade Crossing without Stop Signs, or Warning Systems (reflected across all quadrants).



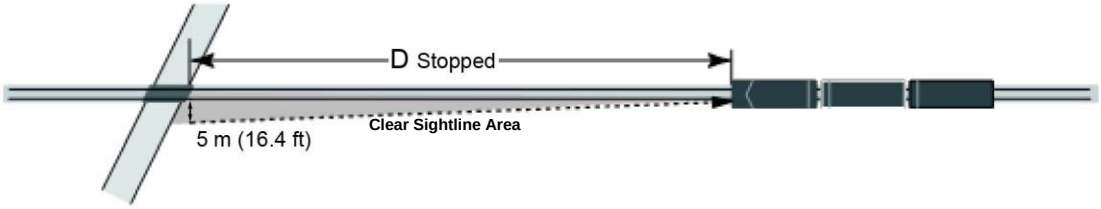
(b) Minimum Sightlines for Drivers Stopped at a Grade Crossing with Railway Crossing Signs, Stop Signs or Warning Systems without Gates (reflected across all quadrants)



(c) Minimum Sightlines for Drivers Stopped at a Grade Crossing without Railway Crossing Signs, Stop Signs, or Warning Systems (reflected across all quadrants)



(d) Minimum Sightlines for Pedestrians, Cyclists and Persons Using Assistive Devices at a Grade Crossing without Gates (reflected across all quadrants)



1. SSD is calculated in accordance with article 1.2.5.2 of the *Geometric Design Guide*.
2. D_{SSD} and $D_{Stopped}$ are obtained in accordance with article 7.5.

8 SIGNS

8.1 Railway Crossing Sign and of the Number of Tracks Sign

8.1.1 A sign providing warning of a grade crossing (Railway Crossing sign) and a sign indicating the number of tracks (Number of Tracks sign) must be as shown in Figure 8-1(a) and (b), must have a retroreflective coating that covers the entire surface of the signs, and

(a) the Railway Crossing sign must have a 50 mm border, transparent red ink silk-screen processed over sheeting material and a 100 mm retroreflective strip must be applied on the back of each blade of the Railway Crossing Sign, for the full length of each blade.

(b) Number of Tracks sign digit and symbol to be transparent red inked silk-screened processed, existing digit and symbol may be black until time of replacement.

8.1.2 A 50 mm retroreflective strip must be applied on the front and back of the Railway Crossing sign supporting posts, extending from no higher than 300 mm above the crown of the adjacent road surface to 70 mm above the centre of the Railway Crossing sign and must be as shown in Figure 8-2.

8.1.3 The retroreflection coefficient of the retroreflective material is to be maintained above 50 per cent of the value specified for Type IV material specified in article 6.1.4 of *ASTM D4956* (cited in Part A).

8.1.4 Retroreflective material must meet the specifications for Type IV material, white sheeting, as specified in sections 4 and 6 of *ASTM D4956* (cited in Part A) when tested in accordance with the Test Methods for Type IV specified in sections 7 and 9 of that Standard.

8.1.5 Railway Crossing sign supporting posts for crossings without a warning system must be of such construction that an 820 kg vehicle striking them at speeds from 32 km/h to 100 km/h will not have a change in velocity greater than 4.57 m per second.

8.1.6 If a road approach crosses adjacent tracks and the minimum distance between track centre lines, measured along the travelled surface parallel to the axis of the road approach, is more than 30 m, each track or set of tracks so separated must have separate Railway Crossing signs.

8.1.7 A sidewalk, path or trail with a centreline that is more than 3.6 m (12 ft.) from a Railway Crossing sign supporting post beside a road approach for vehicle traffic must have separate Railway Crossing signs.

8.1.8 Signs must be located between 0.3 m and 2.0 m from the face of curb, or outer edge of road approach shoulder; or, where there is no curb or shoulder, 2.0 m to 4.5 m from the edge of the travelled way.

8.1.9 Railway crossing signs must be located as shown in Figure 8-3 and clearly visible to all persons approaching the grade crossing on the grade crossing road approach or intersecting road approaches.

8.1.10 Railway Crossing signs must be located as close as possible to the nearest rail but no closer than 3.0 m.

Figure 8-1 – Railway Crossing Sign and Number of Tracks Sign

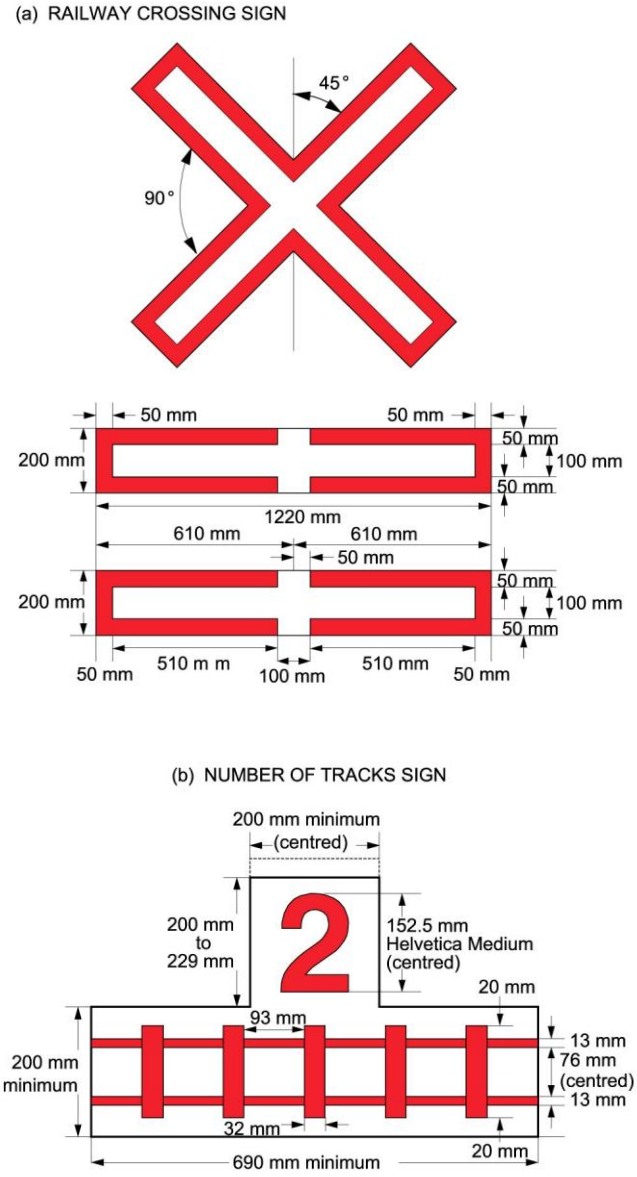


Figure 8-2 – Retroreflective Stripes on the Back of the Railway Crossing Sign and on the Sign Supporting Post (public grade crossings without a grade crossing warning system)

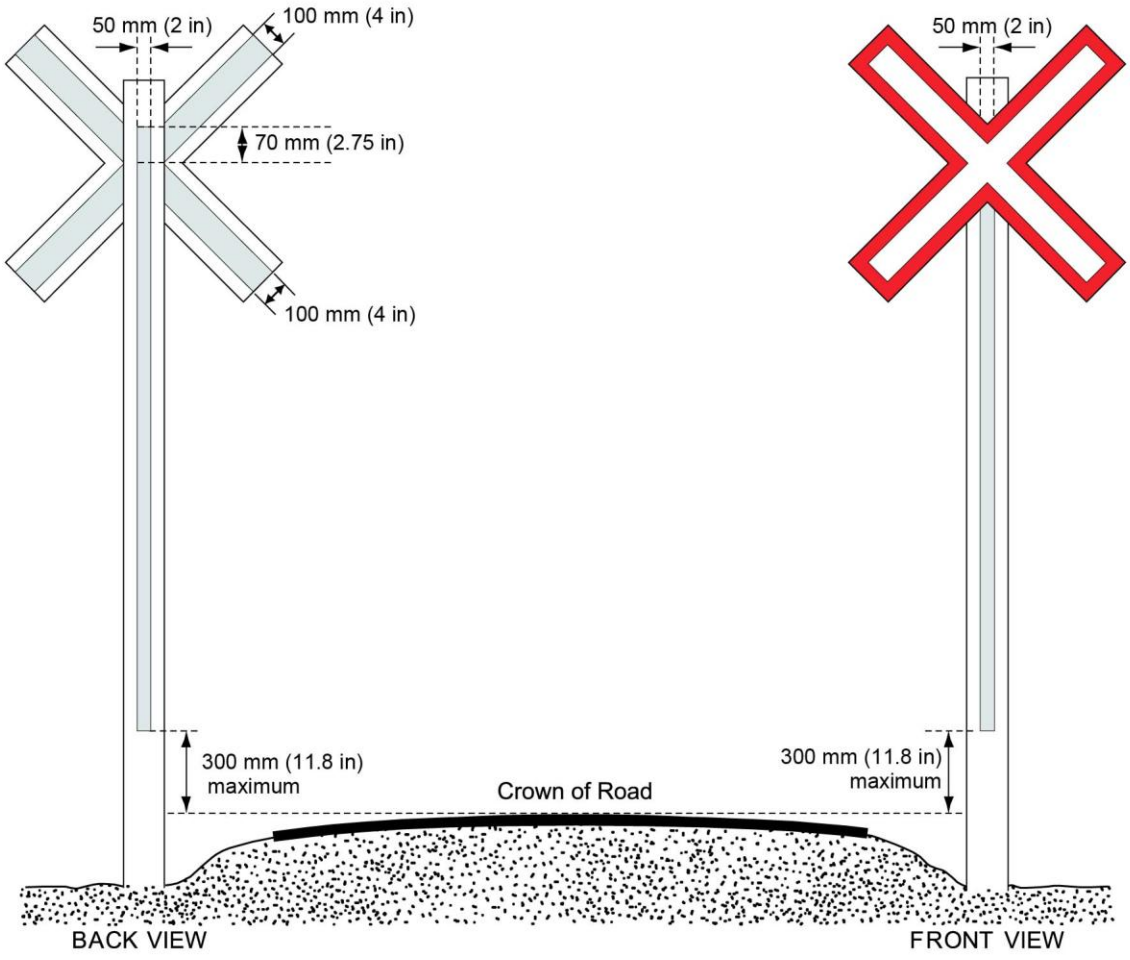
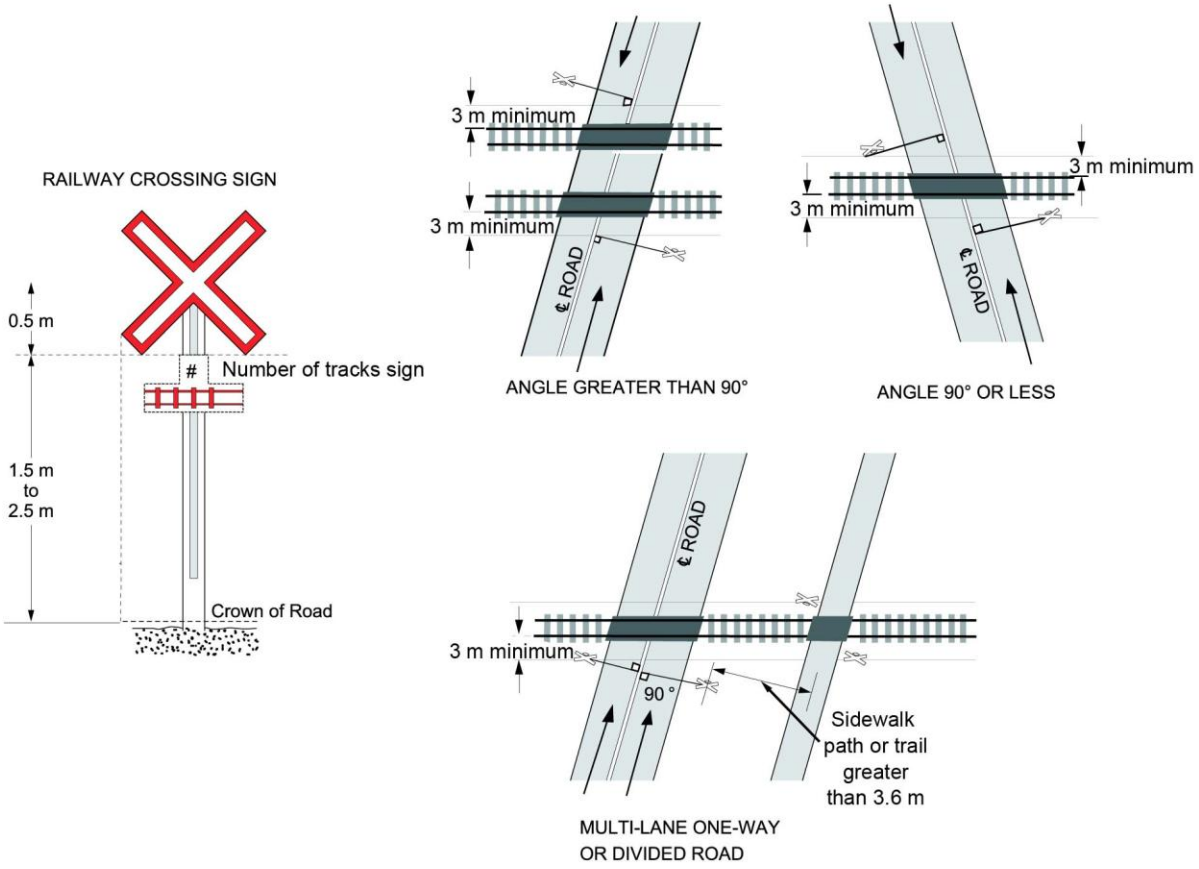


Figure 8-3 – Location of Railway Crossing Signs and Number of Tracks Signs (public grade crossings without warning systems)



8.2 Railway Crossing Ahead Sign and Advisory Speed Tab Sign

8.2.1 A sign providing advanced warning of a grade crossing (Railway Crossing Ahead sign) and a sign specifying a recommended speed (Advisory Speed Tab sign) must be as shown in articles A3.4.2 and A3.2.5 in the *Manual of Uniform Traffic Control Devices for Canada* (cited in Part A) and must meet the applicable specifications A1.6 of that Manual, as the case may be.

8.3 Stop Ahead Sign

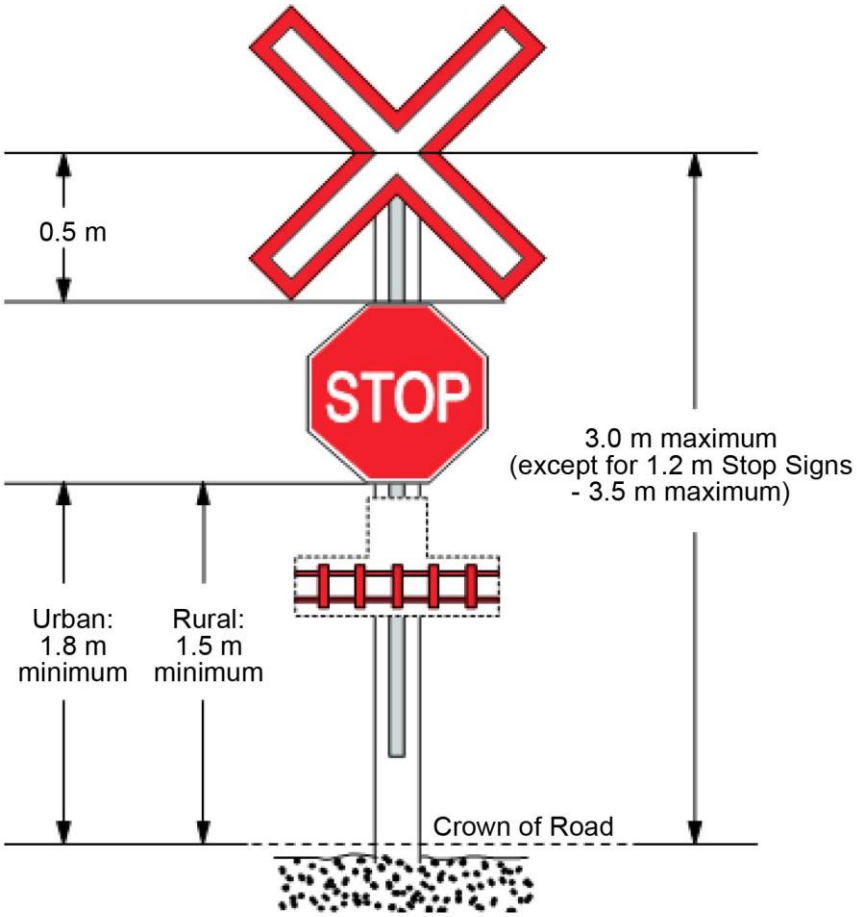
8.3.1 Stop Ahead sign must be as shown in article A3.6.1 of the *Manual of Uniform Traffic Control Devices for Canada* (cited in Part A) and must meet the applicable specifications A1.6 of that Manual.

8.4 Stop Sign

8.4.1 Stop sign must be as shown in article A2.2.1 of the *Manual of Uniform Traffic Control Devices for Canada* (cited in Part A) and must meet the applicable specifications A1.6 of that Manual. Where required by law, the word “Arrêt” will replace the word “Stop”, or may be added to the Stop Sign.

8.4.2 When a Stop sign is installed on the same signpost as a Railway Crossing sign, it must be installed as shown in Figure 8-4.

Figure 8-4 – Stop Signs



8.5 Emergency Notification Sign

8.5.1 An Emergency Notification sign must be oriented so as to face highway vehicles stopped at the grade crossing or on the travelled way near the crossing and must be clearly legible to road vehicles and maintained in good condition.

9 WARNING SYSTEMS SPECIFICATION

9.1 Specifications for grade crossings with warning systems:

9.1.1 The specifications for a grade crossing at which a warning system is required are as follows:

(a) the forecast cross-product is 2,000 or more and the railway design speed is more than 25 km/h (15 mph); or

(b) the grade crossing does not include a sidewalk, path or trail and the railway design speed is more than 129 km/h (80 mph); or

(c) the grade crossing includes a sidewalk, path or trail and the railway design speed is more than 97 km/h (60 mph); or

(d) it is a public grade crossing where the railway design speed is more than 25 km/h (15 mph) and there are two or more lines of railway at the grade crossing where railway equipment may be passing one another; or

(e) it is a public grade crossing where the railway design speed is more than 25 km/h (15 mph), and the distance between the front of a vehicle stopped at a Stop Sign or traffic signal on the departure lane of a grade crossing, and the nearest rail in the crossing surface is:

(i) less than 30 m for a Stop sign, as shown in Figure 9-1(a); or

(ii) 30 m or more for a Stop sign, if a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface, as shown in Figure 9-1(a); or

(iii) less than 60 m for traffic signals, as shown in Figure 9-1(b); or

(iv) 60 m or more for traffic signals, if a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface, as shown in Figure 9-1(b); or

(f) it is a public grade crossing where the railway design speed is more than 25 km/h (15 mph) and a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail of a crossing surface.

9.1.2 Specifications for a grade crossing at which a warning system is required for a sidewalk, path or trail that is outside the range of the island circuit of an adjacent warning system are as follows:

(a) at a grade crossing where the railway design speed is more than 97 km/h (60 mph); or

(b) at a public grade crossing where the railway design speed is more than 25 km/h (15 mph) and there are two or more lines of railway at the grade crossing where railway equipment may be passing one another.

9.2 Specifications for grade crossings with warning systems with gates:

9.2.1 The specifications of a grade crossing at which a warning system with gates is required are as follows:

(a) the forecast cross-product is 50,000 or more; or

(b) the railway design speed is more than 81 km/h (50 mph); or

(c) there are two or more lines of railway where railway equipment may be passing one another; or

(d) the railway design speed is more than 25 km/h (15 mph), and the distance between the front of a vehicle stopped at a Stop Sign or traffic signal on the departure lane of a grade crossing, and the nearest rail in the crossing surface is:

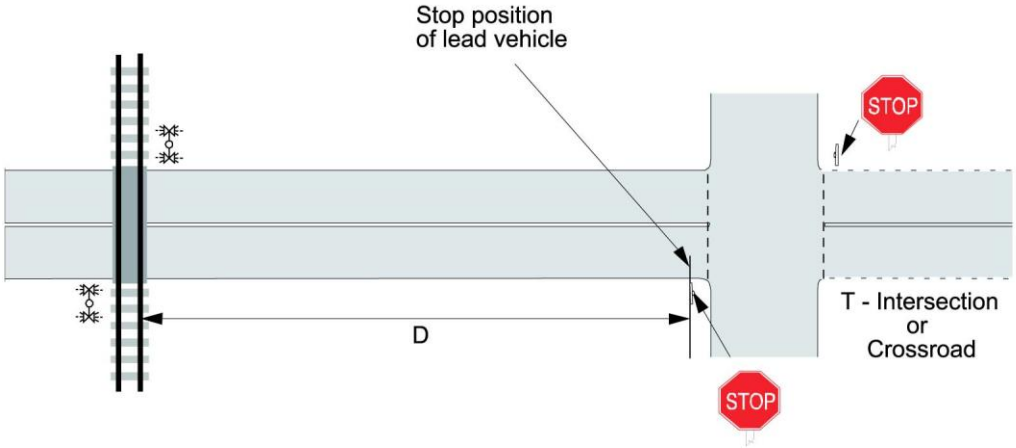
(i) less than 30 m for a Stop sign or less than 60 m for traffic signals; or

(ii) 30 m or more for a Stop sign, or 60 m or more for traffic signals, if a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface, as shown in Figure 9-1; or

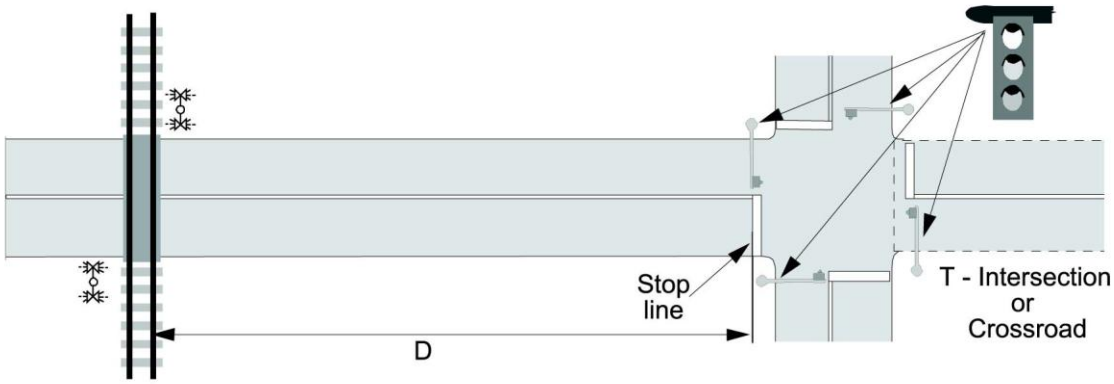
(e) it is a public grade crossing where the railway design speed is more than 25 km/h (15 mph) and a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface.

Figure 9-1 – Proximity of Warning Systems to Stop Signs and Traffic Signals

(a) Near Stop Signs



(b) Near Traffic Signals



PART D – DESIGN CALCULATIONS

10 DESIGN CONSIDERATIONS

10.1 Clearance Distance

10.1.1 Clearance distance (cd) is the distance between the clearance point in advance of the grade crossing, to the clearance point beyond the farthest rail, as shown in Figure 10-1.

10.1.2 Clearance point is the closest point on the departing lane of a grade crossing that is 2.4 m from the nearest rail measured perpendicular to the rail.

10.2 Vehicle Travel Distance

10.2.1 The total distance the vehicle must travel to pass completely through the clearance distance in Figure 10-1 is calculated using the following formula:

$$\mathbf{s} = cd + L$$

Where,

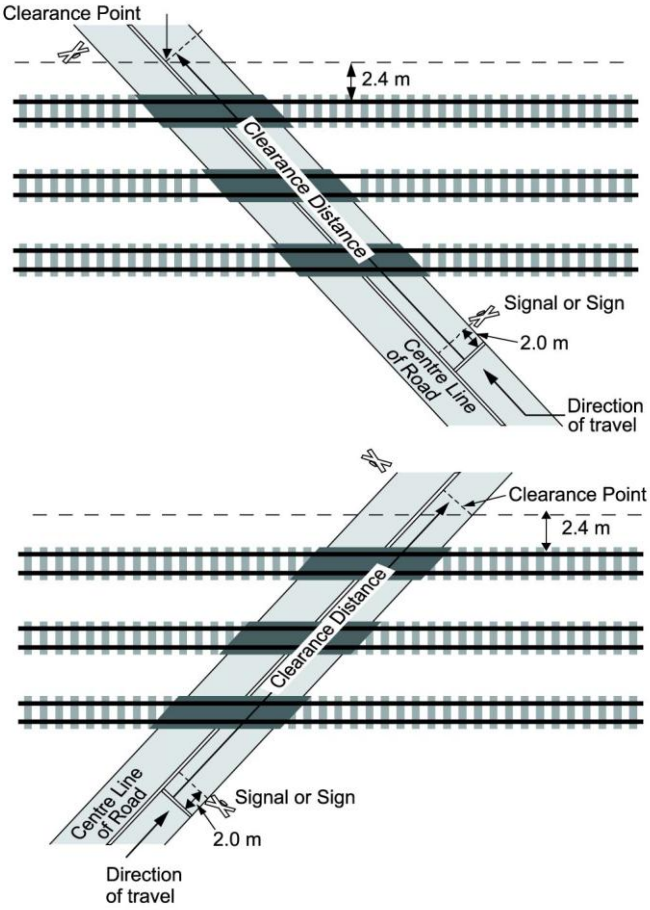
s = distance the road vehicle must travel to pass through the grade crossing clearance distance (m);

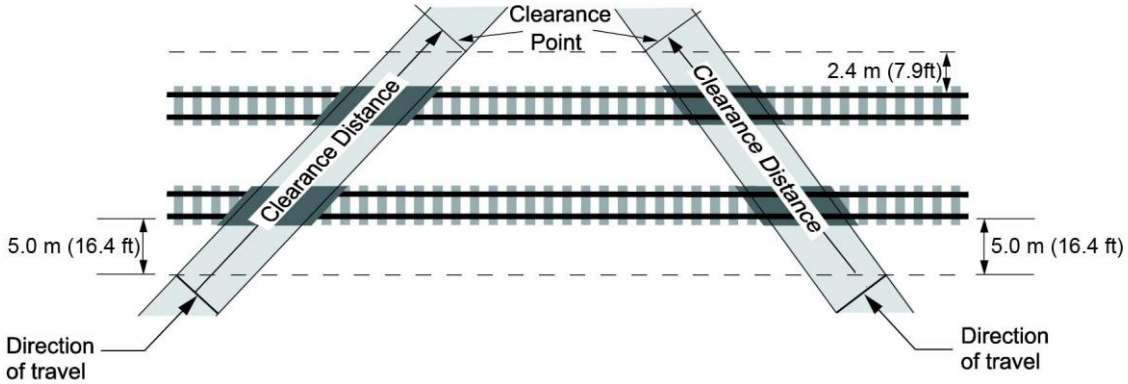
cd = clearance distance [Figure 10-1]; and

L = length of the grade crossing design vehicle [Table 10-1].

Figure 10-1 – Clearance Distance for Grade Crossings

(a) Signs or Signals





10.3 Departure Time - General

10.3.1 From a stopped position, the design vehicle departure time (TD) is the time required for the design vehicle to pass completely through the clearance distance (cd). It includes the time required for the driver to look in both directions along the rail line and to accelerate and move the vehicle completely through the clearance distance.

The grade crossing design vehicle departure time depends on the clearance distance, the length of the design vehicle and the vehicle's acceleration.

When calculating vehicle departure time for the design vehicle, the following factors affecting vehicle acceleration must be taken into consideration:

(a) the condition of the road surface, including the crossing surface, snow conditions and treatment of ice that affect vehicle traction on the road surface;

(b) the design vehicle rate of acceleration related to mass/power ratios;

(c) physical conditions present at grade crossings that increase the time required for vehicles to pass through the grade crossing clearance distance. These conditions include:

i. condition of the road surface;

ii. condition of the crossing surface;

iii. super elevated track at the grade crossing;

iv. an intersection on the departure side of the grade crossing where vehicles are required to stop, which reduces vehicle acceleration over the crossing;

v. restrictions on the vehicle operator from shifting gears while passing over the grade crossing;

vi. non-standard placement of stop line pavement markings; and

vii. average gradient of the road over the clearance distance.

Table 2.3.3.2 of the *Geometric Design Guide* must be used to account for the effects of road gradient using the design vehicle and must be incorporated into the acceleration time of a general design vehicle on level ground by multiplying the acceleration time on level ground by a constant ratio relating to the road gradient.

10.3.2 Determination of Design Vehicle Departure Time

The *design vehicle departure time* (T_D) is calculated as follows:

$$T_D = J + T$$

Where,

J = 2 seconds perception-reaction time for the driver to look in both directions, shift gears, if necessary, and prepare to start; and

T = the time for the grade crossing design vehicle to travel through the vehicle travel distance (**s**) (Article 10.2).

T may be obtained through direct measurement or calculated using the following formula:

$$T = (t \times G) + K$$

Where,

t = time for the grade crossing design vehicle to accelerate through the distance **s** from Figure 2.3.3.3 of the *Geometric Design Guide*;

G = ratio of acceleration time on grade from Table 2.3.3.2 of the *Geometric Design Guide*; and

K **=** the additional time required for the grade crossing design vehicle's acceleration through the clearance distance due to the grade crossing conditions (based on operational characteristics of the crossing).

10.3.3 Departure Time – Pedestrians, Cyclists and Persons Using Assistive Devices

The departure time for pedestrians (T_p) must be calculated as follows:

$$T_p = \frac{cd}{V_p}$$

Where,

cd = clearance distance (m) (Article 10.1); and

V_p = travel speed pedestrians, cyclists, and persons using assistive devices (max 1.22 m/s).

10.4 Gate Arm Clearance Time

10.4.1 Gate arm clearance time is the greater of **$T_{G\ ssd}$ or $T_{G\ stop}$**:

- the time it takes a design vehicle to go from SSD to pass the gate arm (**from SSD**); and

Gate Arm Clearance Time from SSD is calculated as follows:

$T_{G\ ssd}$ = Gate Arm Clearance Distance from SSD/Maximum Road Operating Speed(s)

Where: SSD is obtained from article 1.2.5.2 of the *Geometric Design Guide*

Gate Arm Clearance Distance from **SSD** (m) = SSD + 2 m + Grade Crossing Design Vehicle Length

- the time it takes the design vehicle to start from a stopped position to pass the gate arm (**from STOP**).

Gate Arm Clearance Time from stop is calculated as follows:

$T_{G\ stop}$ = J + ((t x G) + K)

Where,

J = 2 seconds perception-reaction time of the driver to look in both directions, shift gears, if necessary, and prepare to start;

t = time for the grade crossing design vehicle to accelerate through the Gate Arm Clearance Distance from stop from Figure 2.3.3.3 of the *Geometric Design Guide*;

G = ratio of acceleration time on grade from Table 2.3.3.2 of the *Geometric Design Guide*

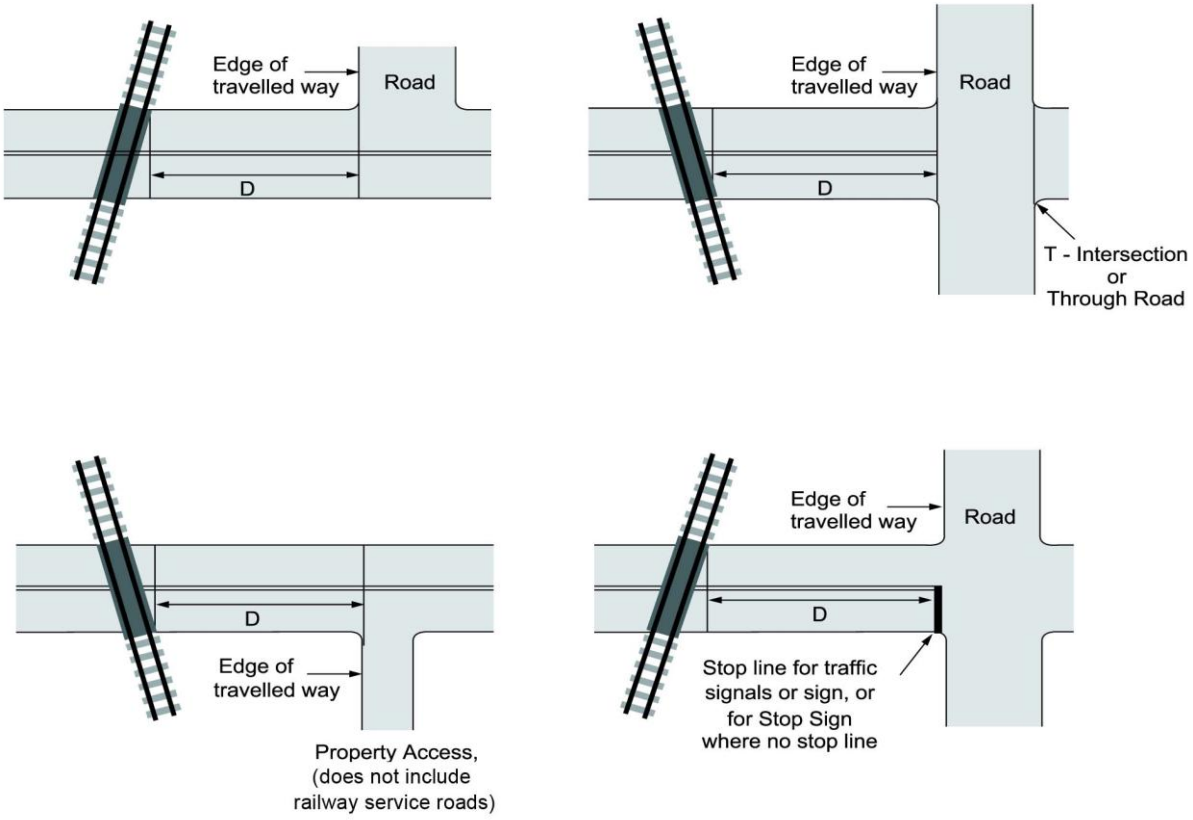
K = the additional time required for the grade crossing design vehicle's acceleration through the clearance distance due to the grade crossing conditions (based on operational characteristics of the crossing).

Gate Arm Clearance Distance from a **stop** (m) = 2 m + Grade Crossing Design Vehicle Length

11 LOCATION OF GRADE CROSSINGS

11.1 A public grade crossing where the railway design speed is more than 25 km/h (15 mph) must be constructed so that no part of the travelled way of an intersecting road or entranceway (other than a railway service road), or the stop line or position of a traffic control device is closer than 30 m to the nearest rail of the grade crossing (see Figure 11-1).

Figure 11-1 – Restrictions on the Proximity of Intersections and Entranceways to Public Grade Crossings



D not less than 30 m where the railway design speed is 25 km/h (15 mph) or more.

PART E – WARNING SYSTEM DESIGN

12 WARNING SYSTEM OPERATION - GENERAL

12.0 Except as otherwise specified in articles 12 to 16 and Appendix B of these standards or in the *Grade Crossings Regulations*, warning systems must be in accordance with the requirements and recommended practices of Part 3 of the *AREMA Communications and Signals Manual* (cited in Part A).

12.01 For the purposes of these Standards, the following interpretations and adjustments apply with respect to AREMA:

(a) Any guidelines, recommendations, requirements and similar matters set out in a document that is incorporated into these Standards are to be considered mandatory;

(b) Any references to “should” are to be read as “must”;

(c) The term “highway-rail grade crossing warning system” is to be read as “warning system”;

(d) The term “railroad” and the phrase “operators of the passenger or commuter rail system” is to be read as “railway company”;

(e) The term “lights” is to be read as “light units”;

(f) The term “train” is to be read as “railway equipment”;

(g) The term “roadway” and “roadway approach” is to be read as “road approach”;

(h) The reference to the “MUTCD” is to be read as “MUTCDC (Manual of Uniform Traffic Control Devices for Canada)”

(i) All “Purpose” article s, paragraph 2 of article 3.1.16(G)(b)(ii) and article 3.2.35(K)(5) are to be disregarded;

(j) The following are to be disregarded:

(i) all references to and requirements related to the “Diagnostic Team”;

(ii) all references to and requirements related to the “highway agency” or “highway agency or authority with jurisdiction”;

(iii) all references to and requirements related to the “agency” or “public agency”;

(iv) all references to and requirements related to “manufacturers” except where the requirement is to do something in accordance with the manufacturer’s instructions;

(v) all references to “unless otherwise specified” or “other considerations”, all references to approvals or orders, and any other reference to the exercise of discretion;

(vi) all purchase order requirements;

(vii) all record creating or keeping requirements;

(viii) all requirements for a diagnostic review, engineering study and study of train operations.

12.1 Each wire must be tagged or marked and be identified at each terminal. Tags and other marks of identification must be made of insulating material and arranged so that tags and wires do not interfere with moving parts of the apparatus. This requirement applies to each wire at each terminal in all housings including switch circuit controllers and terminal or junction boxes. This requirement does not apply to flashing light units, gate arm light units and other auxiliary light units. The local wiring on a solid state crossing controller rack does not require tags if the wiring is an integral part of the solid state equipment.

12.2 Warning signal assemblies must be as shown in Figure 12-1, gates must be as shown in Figure 12-2 and cantilever clearance must be as shown in Figure 12-3, and must meet the following specifications:

(a) The minimum clearance distance must be 625 mm (2 ft) from the face of a curb;

(b) Where there is no curb, the minimum clearance distance must be 1.875 m (6ft) from the edge of the travelled way and a minimum of 625 mm (2 ft) from the outer edge of the road approach shoulder, if there is one;

(c) The top of the warning signal foundation must be not more than 100 mm (4 inches) above the level of the surrounding ground. The slope away from the foundation of the surrounding ground towards the travelled way of the road approach and the road approach shoulders must not exceed the ratio of 4:1;

(d) The gate arm reflective materials shall have:

(i) stripes of 406 mm (16 inches), and must be affixed with white and red alternately and be aligned vertically;

(ii) Retroreflective material: must meet the specifications for Type XI, white sheeting, in sections 4 and 6 of *ASTM D4956* (cited in Part A), when tested in accordance with the Test Methods for Type XI specified in sections 7 and 9 of that Standard.; and

(iii) Sheeting must be replaced before the retroreflection coefficient of the retroreflective material is less than 50 per cent of the value specified for the material stated in (ii).

(e) For grade crossings used by vehicles, gate arms must extend to within 1 m (3 ft) of the farthest edge of that portion of the road approach. Where gates are installed on each side of the same road approach, gate ends must extend to within 1 m (3 ft) of each other.

(f) Where gates are installed for grade crossings exclusively for pedestrians, cyclists, or both:

(i) Each gate arm must extend across the full width of the travelled way.

(ii) When the travelled way is less than 3.5 m (11.5 ft.) wide, two lights are required on each gate arm located so that the lights are over the two points dividing the travelled way into thirds. The two gate arm lights must flash alternately.

12.3 In addition, warning systems must have monitoring devices that gather and retain the following the following information:

i) Pre-emption activation (FR)

ii) Gate up indication

iii) Gate down indication

iv) Test switch activation

v) Track circuits activation: conventional crossing

vi) Grade crossing predictor status: constant warning system

vii) Output of detection circuit (XR)

viii) GCP: Output

ix) Centre track circuit: XT

x) DAX input/output

12.4 All control circuits that affect the safe operation of a warning system must operate on the fail-safe principle (the failure of any safety-critical component or system must result in the operation of the warning devices).

12.5 The electromagnetic, electronic, or electrical apparatus of a warning system must be operated and maintained in accordance with the limits within which the system is designed to operate.

12.6 Railway equipment detection apparatus must:

(a) detect railway equipment in any part of the detection circuit;

(b) detect the application of a shunt of 0.06 ohm resistance when the shunt is connected across the track rails of any part of the circuit; and

(c) provide a set of fouling wires which consist of at least two discrete conductors and must ensure proper operation of the detection apparatus when the detection circuit is shunted. Single duplex wire with single plug is not permitted.

(d) in the case of a non-insulated rail joint within the limits of a detection circuit, be bonded by means other than joint bars and the bonds must ensure electrical conductivity.

(e) in the case of an insulated rail joint used to separate detection circuits, prevent current from flowing between rails separated by the insulation.

12.7 Warning system battery back-up of 8 hours of continuous activation and 24 hours of normal railway operations must be provided.

Figure 12-1 – Warning Signal Assemblies

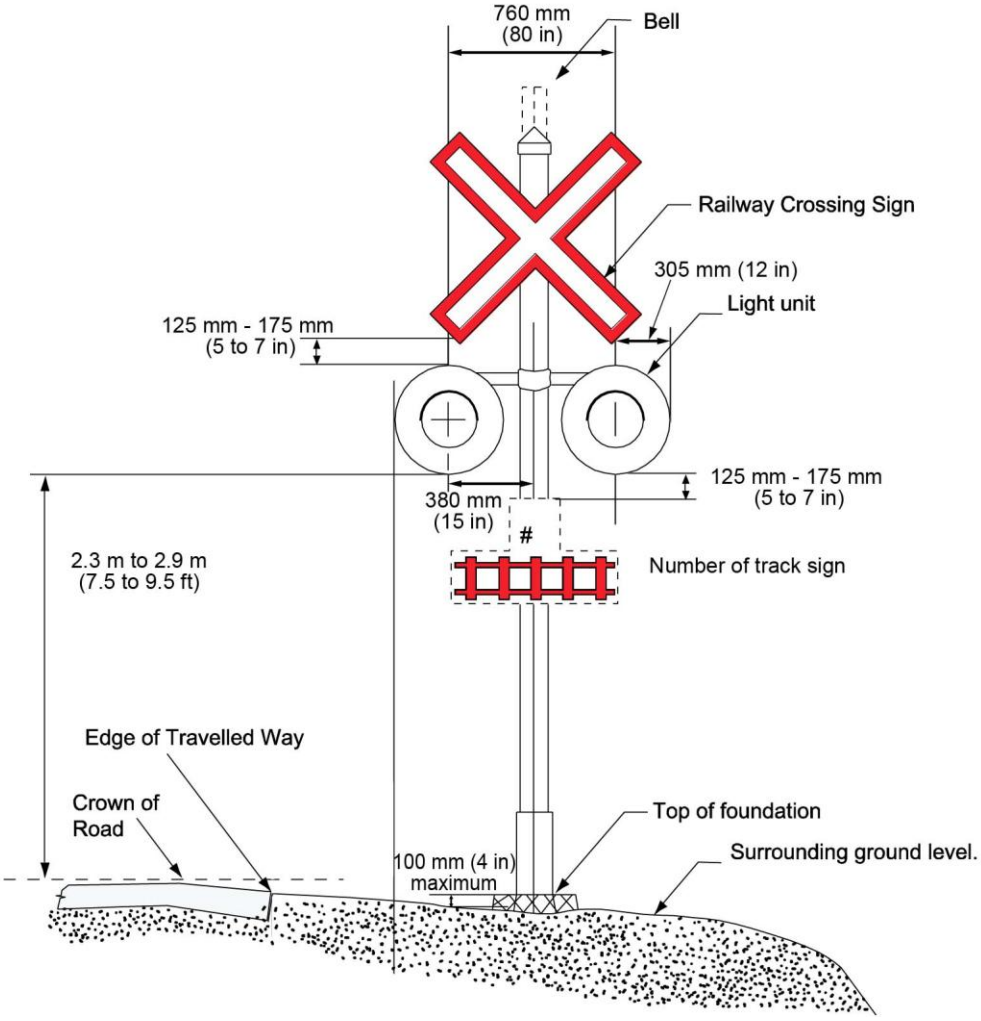


Figure 12-2 – Gates

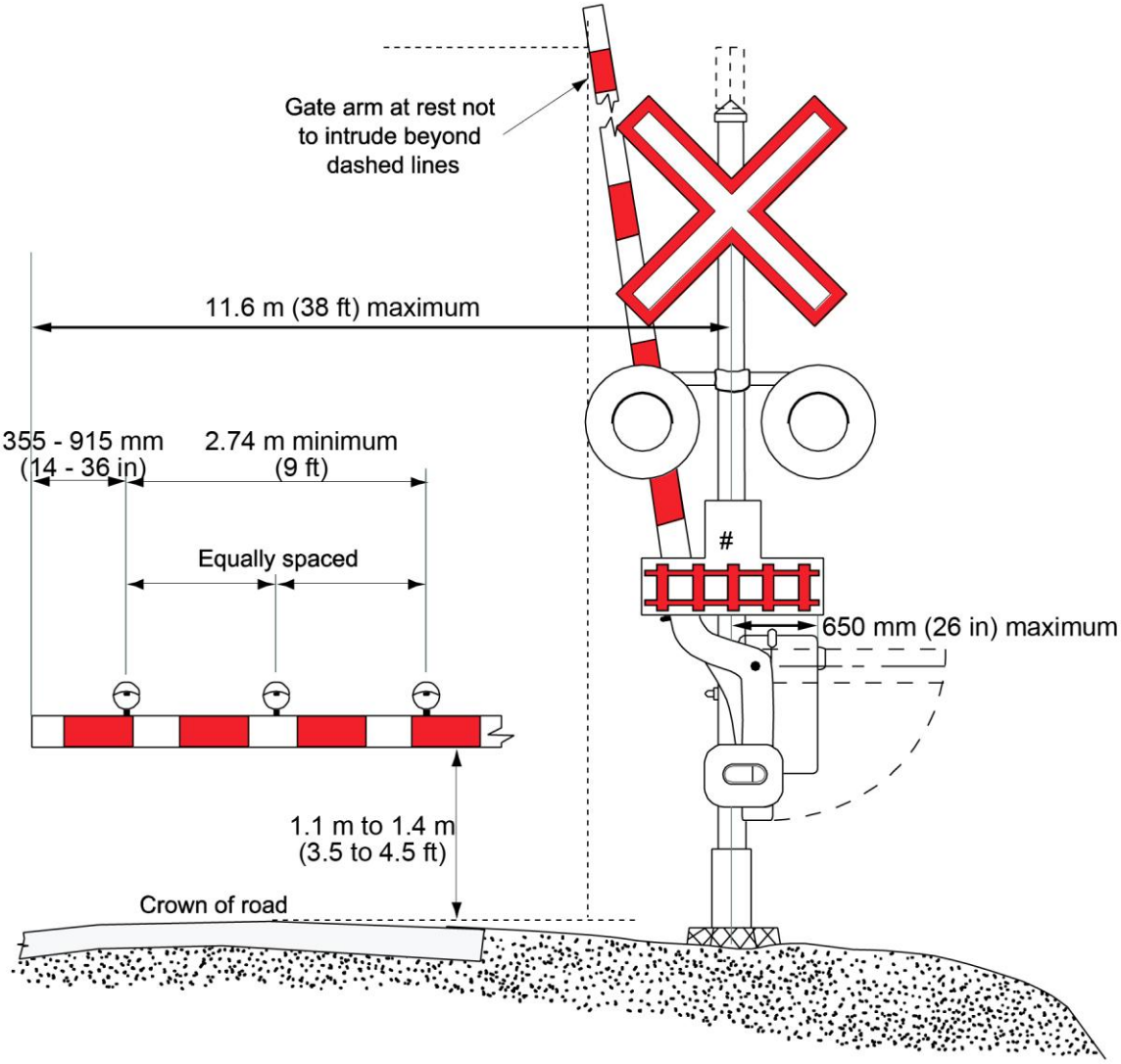
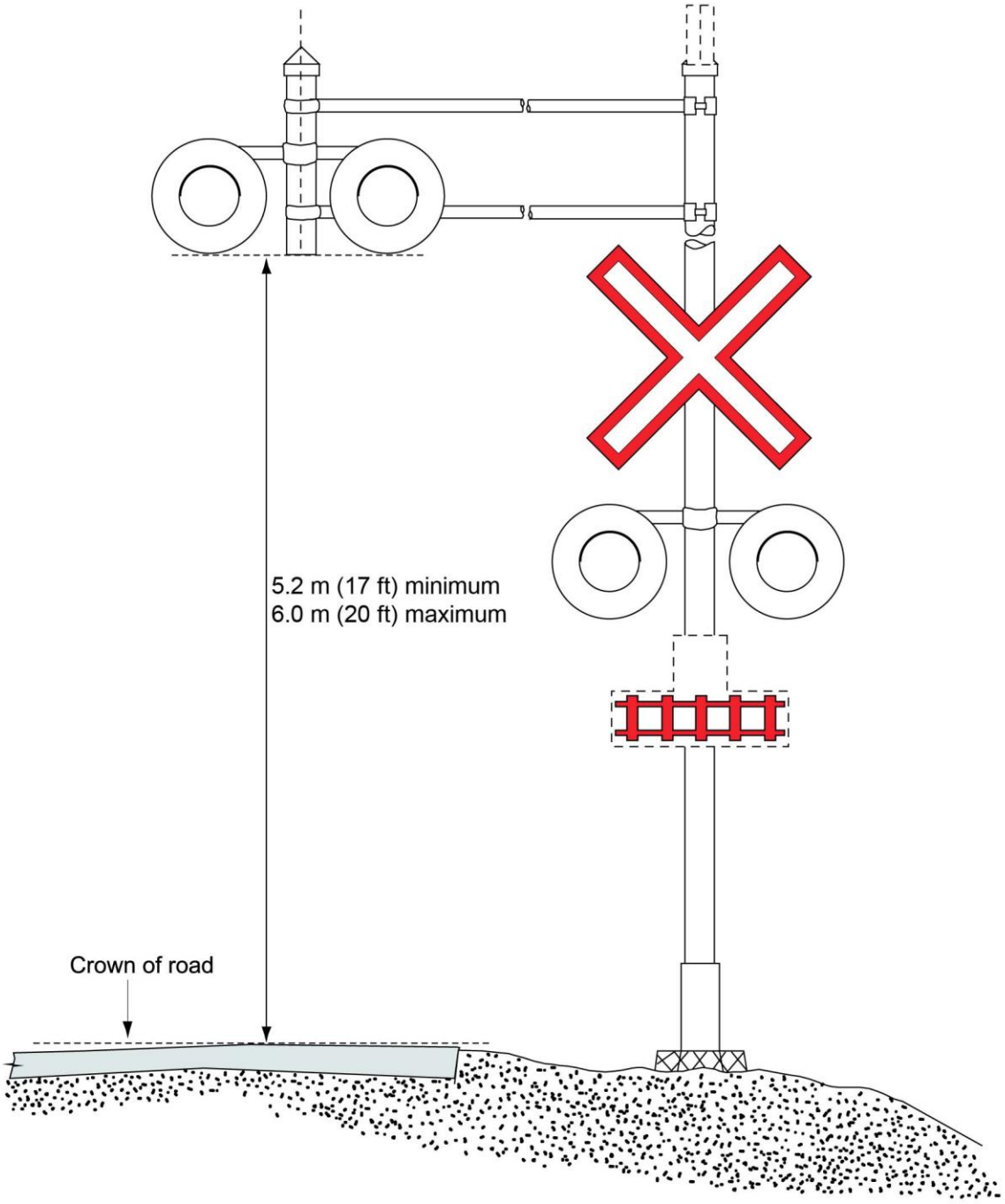


Figure 12-3 – Cantilevers



13 NUMBER AND LOCATION OF FLASHING LIGHT UNITS

13.1 Sufficient light units must be provided in a warning system and located to ensure that a driver, in each lane or a road approach, or at intersecting road approaches, parking lots or other property access:

(a) is within the effective distribution pattern of luminous intensity of a set of light units within the distances specified for the primary front light units in article 14.4, or from a road intersection or a property access;

(b) is able to clearly see at least one set of front light units.

13.2 Sufficient light units must be provided in a warning system and located to ensure that all drivers stopped at the grade crossing, in each lane;

(a) are within the effective distribution pattern of luminous intensity of a set of back lights;

(b) so that at least one set of back lights is clearly visible to drivers in each lane, except for when the visibility of the light units is obstructed by railway equipment.

13.3 Cantilevered Light Units

13.3.1 Cantilevered light units must be provided in warning systems if:

(a) the distance between the farthest edge of the travelled way of the road approach lane(s) approaching the grade crossing and a grade crossing warning signal mast exceeds the limits of Figure 13-1;

(b) the front light units of the grade crossing warning signal (i.e. those on the same side of the track as approaching traffic) are not clearly visible within the distance for the primary set of light units as specified in article 15.4,

13.3.2 Cantilevered light units must be provided in warning systems installed on road approaches that meet the specifications for a freeway or expressway as specified in Chapter 1.3 of the *Geometric Design Guide.*

13.4 Light Units for Horizontal and Vertical Curvature of Road Approaches

13.4.1 Additional light units must be installed where the horizontal curvature in the road approaches make them necessary to provide complete coverage between the back light units and the primary front light units.

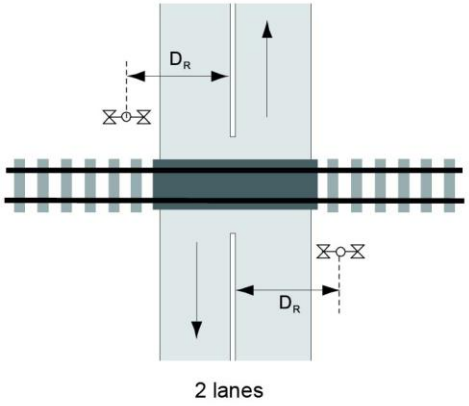
13.5 Light Units for a Sidewalk, Path or Trail

13.5.1 A sidewalk, path or trail with a centre line more than 3.6 m (12 feet) from a warning signal mast beside the travelled way of a road approach for vehicles must have separate light units, as shown in Figure 13-2.

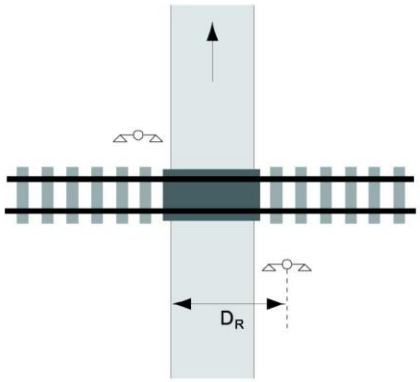
13.5.2 A set of back lights must be provided for persons travelling in the direction opposite to vehicle traffic where there is a sidewalk, paths or trail along one-way road approach as shown in Figure 13-2.

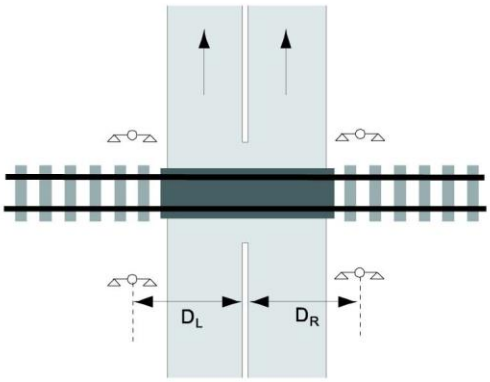
Figure 13-1 – Warning Signal Offsets Requiring Cantilevered Light Units

(a) Two-Way



(b) One-Way or Divided

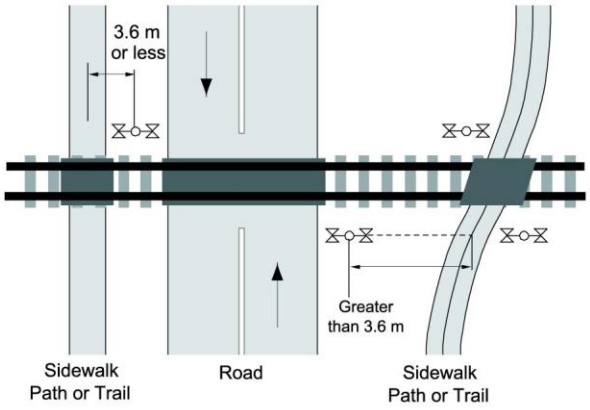




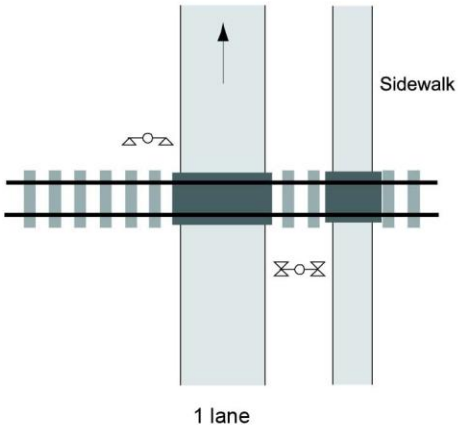
1. Where “DR” is more than 7.7 m, cantilevered light units are required.
2. Where “DL” is more than 8.7 m, cantilevered light units are required.
3. Distances measured at 90 degrees to the centre line of the road approach.

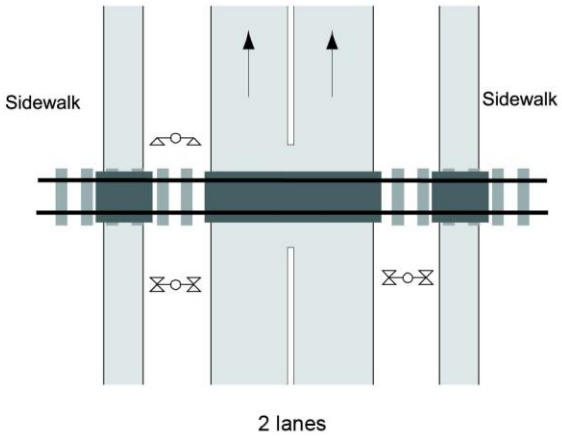
Figure 13-2 – Sidewalks, Paths and Trails

(a) Two Way



(b) One-Way





14 LIGHT UNITS - ALIGNMENT

14.1 General – Light Units

14.1.1 Light units must be of the 200 mm and the 300 mm Light Emitting Diode (LED) signal module type as specified in Appendix A of the *GCS* (cited in Part A).

14.1.2 Sets of light units of warning systems must flash alternately and uniformly at a rate of 45 to 65 flashes per minute.

14.1.3 Light unit voltage must be maintained between 90 and 110 per cent of the rated voltage under standby power conditions.

14.2 Light Unit Alignment

14.2.1 The alignment point of the axis of light units must be appropriate for the conditions at each grade crossing. They must be aligned for approaching drivers, taking into consideration the road design speed and the distance at which the light units first can be seen.

14.2.2 Each gate arm light units must be maintained and aligned in such condition to be properly visible to approaching road users.

14.3 Alignment Height – Front and Back Lights

14.3.1 Light units must be aligned so that the axes of the light units pass through a point 1.6 m above the road approach surface at the required distance.

14.4 Alignment Distance – Primary Front Light Units for Vehicles

14.4.1 Warning System light unit visibility distance is defined as the distance in advance of the stop line or vehicle stop position from which a set of light units must be continuously visible for various approach speeds.

14.4.2 Sets of primary front light units on the warning signal, and on a cantilever structure where provided, must be aligned through the centre of the approaching traffic lane, or lanes, for which they are intended, at:

(a) a minimum distance of the stopping sight distance calculated in accordance with article 1.2.5.2 of the *Geometric Design Guide*; or

(b) the point at which the light units are first clearly visible, if this point is less than the distance specified in 14.4.2(a).

(c) Additional light units as required by article 12 must be aligned to provide intermediate coverage of the road approach.

14.5 Alignment – Intermediate Front Light Units for Vehicles

14.5.1 Additional sets of light units must be aligned to cover any intermediate areas of the road approaches between the coverage provided by the primary front light units aligned as required in article 14.4 and the back lights aligned as required in article 14.6.

14.5.2 Additional sets of light units provided for a driver turning onto the road approach to a grade crossing from intersecting road approaches, lanes, parking lots or other property access must be aligned through the point above the road approach at which the drivers begin their turns.

14.5.3 Once the requirements of articles 14.5.1 and 14.5.2 are satisfied, any remaining front or back lights must be aligned to reinforce the coverage along the road approach.

14.6 Alignment – Back Light Units for Vehicles

14.6.1 At least one set of back light units must be aligned through the centre of the approaching lanes, or separate traffic lanes for which they are intended, 15 m (50 ft) in advance of the crossing warning signal on the opposite approach.

14.7 Alignment – Light Units Dedicated to a Sidewalk, Path or Trail

14.7.1 Light units for persons on a sidewalk, path or trail, including sets of light units provided for persons approaching the crossing from the direction opposite to the vehicular traffic on a one-way road approach, must be aligned through a point 1.6 m above the centre of the sidewalk, path or trail 30 m (100 ft) in advance of the nearest rail or the point at which the set of lights units first become visible if less than 30 m.

15 BELLS AND GATES

15.1 Bells

15.1.1 A bell is required for all warning systems, except for limited use warning systems referred to in Appendix B and for limited use warning systems with walk lights referred to in Appendix C.

15.1.2 Where there is only one sidewalk, path or trail along a road approach, the bell must be located on the signal mast adjacent to the sidewalk, path or trail.

15.1.3 A bell is required on a signal mast adjacent to a sidewalk, path or trail if separated from any other signal mast with a bell by more than 30 m.

15.1.4 All bells must continue to operate until the activation of the warning system has ceased.

15.2 Gates

15.2.1 The descent of the gate arm must take 10 to 15 seconds and its ascent must take 6 to 12 seconds.

15.2.2 The descent of the gate arm must be delayed by the gate arm clearance time calculated in accordance with article 10.4.

15.2.3 A gate arm must rest in the horizontal position not less than 5 seconds before the arrival at the crossing surface of railway equipment at the grade crossing except where the railway equipment enters the grade crossing at 25 km/h (15 mph) or less, in which case the gate arm must rest in the horizontal position by the time railway equipment arrives at the grade crossing.

15.2.4 The gate arms must operate uniformly, smoothly, and complete all movements without rebound, and must be securely held when in raised position.

15.2.5 The mechanism must be so designed that if the gate arms, while being raised or lowered, strike or foul any object, they will readily stop and, on removal of the obstruction, the mechanism should assume the position corresponding with the control apparatus.

16 CIRCUITRY

16.1 Warning Time

16.1.1 The warning time of railway equipment approaching a warning system must be based upon the railway design speed on the approach and must be the greatest of:

(a) 20 seconds, unless the grade crossing clearance distance (Figure 10-1) is more than 11 m (35 ft), in which case, the 20 seconds must be increased by one second for each additional 3 m (10 ft), or fraction thereof;

(b) the Departure Time for the grade crossing “design vehicle” (article 10.3.2);

(c) the Departure Time for pedestrians, cyclists, and persons using assistive devices (article 10.3.3);

(d) the gate arm clearance time, plus the time to complete the gate arm descent, plus 5 seconds;

(e) the minimum warning time required for traffic signal pre-emption;

(f) the time for the design vehicle travelling at the design speed to travel from the stopping sight distance, as specified in article 1.2.5.2 of the *Geometric Design Guide* and pass completely through the clearance distance.

16.1.2 The time of operation of the flashing lights before railway equipment operating at the railway design speed enters the crossing must take into account the additional equipment response time and any buffer time as required.

16.2 Consistency of Warning Times

16.2.1 Operating control circuits must provide consistent approach warning times for railway equipment regularly operating over the grade crossing.

16.2.2 Where the railway design speed has been reduced, other than for a temporary slow order, the approach warning times for railway equipment regularly operating over the grade crossing, including railway equipment operating at the maximum permitted speed, may be up to 13 seconds longer than the design approach warning time.

16.3 Cut-Outs

16.3.1 Where railway equipment regularly stops, or railway equipment is left standing, within the activating limits of a warning system, the warning system must be equipped with a special control feature to minimize the operation of the warning system.

16.3.2 A switch, when equipped with a switch circuit controller connected to the point and interconnected with the warning system circuitry, must cut out only when the switch point is within one-half inch of full reverse position.

16.4 Directional Stick Circuits

16.4.1 Where a warning system is equipped with directional stick circuits, the design must include a device to activate the crossing warning system after a preset time if there is failure of an approach circuit, or the warning system operating control circuit must cause a signal system to give a signal aspect indicating a railway equipment speed of 25 km/h (15 mph) or less.

17 WARNING SYSTEMS - MAINTENANCE, INSPECTION AND TESTING

17.1 Maintenance, inspection and testing of warning systems must be done in accordance with article 3.3.30 of AREMA.

Table 17-1 – Interpretation of Frequencies of Maintenance, Inspections and Tests for Warning Systems

COLUMN 1	*COLUMN 2*	*COLUMN 3*
DESIGNATED FREQUENCY	**DEFINITION**	**MAXIMUM INTERVAL: CLEAR DAYS BETWEEN EACH MAINTENANCE, INSPECTION OR TEST**
Immediately	Immediately following the installation, repair, adjustment, maintenance	Not applicable
Weekly	Once every week (Sunday to Saturday)	10 days
Monthly	Once every calendar month	40 days
Quarterly	Once every 3 months (January to March, April to June, July to September, and October to December)	100 days
Twice annually	Once every 6 months (January to June and July to December)	200 days
Annually	Once every calendar year	13 months
Every 2 years	Once every 2 calendar years	26 months
Every 4 years	Once every 4 calendar years	52 months
Every 10 years	Once every 10 calendar years	130 months

Table 17-2 – Required Frequencies of Inspections and Tests for Warning systems

COLUMN 1	*COLUMN 2*	*COLUMN 3*	*COLUMN 4*	*COLUMN 5*
ITEM	***Components and Maintenance, Inspection and Testing requirements***	***Frequency for Warning Systems***	***Frequency for Limited Use Warning Systems***	***Frequency for Limited Use Warning Systems with Walk Light***
1	Warning Systems: for operation of lights, bell, gates, and power off light.	Weekly or no more than 7 days before the operation of railway equipment	N/A	N/A
2	Light units: for obvious misalignment, physical damage and conspicuity.	Monthly	Quarterly	Quarterly

3	Standby power: for operating bank voltage	Monthly	Quarterly	Quarterly
4	Flashing light units, gates, and signs: for damage, cleanliness, and visibility	Monthly	Quarterly	N/A
5	Bell: for operation	Monthly	N/A	N/A
6	Gate arm: for operation	Monthly	N/A	N/A
7	Surge protection: for condition	Monthly, and as soon as possible following electrical storm activity.	Quarterly	Quarterly
8	Circuits: for grounds	Monthly	Quarterly	Quarterly
9	Battery: for isolation faults	Monthly	Quarterly	Quarterly
10	Storage batteries: for voltage, current, electrolyte level, and plate deterioration where plates are visible	Monthly	Quarterly	Quarterly
11	Interconnection components: for proper energization of circuits.	Monthly	N/A	N/A
12	Switch circuit controller: for adjustment	Quarterly	Quarterly	Quarterly
13	Primary batteries: for degree of exhaustion, voltage and current	Quarterly	Quarterly	Quarterly
14	Fouling circuits: for continuity	Quarterly	Quarterly	Quarterly
15	Direct Current relays: visual check of condition	Twice Annually	Twice Annually	Twice Annually
16	Bond wires, track connections, insulated joints, and other insulated track appliances: visual check of condition	Twice Annually	Twice Annually	Twice Annually
17	Cut-out circuits (any circuit that overrides the operation of a warning system) : for operation	Twice Annually	Twice Annually	Twice Annually
18	Gate mechanism and circuit controller: visual inspection of condition	Twice Annually	N/A	N/A
19	Control circuits of Traffic Signals installed at a grade crossing in lieu of a warning system: for operation	Twice Annually	N/A	N/A
20	Light units: for proper alignment, focus, and visibility. For incandescent lights, open light units and check the focus of the lamp and reflector by observing the parallel beam of light at the prescribed distance, and check the cleanliness and condition of the reflector and lens	Annually	Annually	Annually
21	Light Unit: for voltage	Annually	Annually	Annually
22	Track circuits: for proper functioning	Annually	Annually	Annually

23	Flash controller: for flash rate	Annually	Annually	Annually
24	Battery: load test	Annually	Annually	Annually
25	Warning time: for required time	Annually	Annually	Annually
26	Electronic railway equipment detection devices, including processor-based systems: for programming and function ability.	Annually	Annually	Annually
27	Timing relays and timing devices: for required time	Annually	Annually	Annually
28	Cable and wire entrances: for condition	Annually	Annually	Annually
29	Switch circuit controller centering device: for condition	Annually	Annually	Annually
30	Interconnection output between of warning systems and traffic control devices: for operation	Annually	N/A	N/A
31	Pole line and attachments: for condition	Every Two Years	Every Two Years	Every Two Years
32	Gate mechanism: for electrical values, mechanical clearances and torque	Every Two Years	Every Two Years	Every Two Years
33	DC Polar, AC Vane, and Mechanical Timer relays: for electrical values and operating characteristics	Every Two Years	Every Two Years	Every Two Years
34	Relays that affect proper functioning of a warning system (except for DC polar, AC Vane and Mechanical Timer): for electrical values and operation	Every Four Years	Every Four Years	Every Four Years
35	Ground: for resistance value	Every Four Years	Every Four Years	Every Four Years
36	Wire and cable insulation: for resistance	Every Ten Years	N/A	N/A

PART F – INTERCONNECTED DEVICES

18 PREPARE TO STOP AT RAILWAY CROSSING SIGN

18.1 The Prepare to Stop at Railway Crossing sign, as shown in A3.6.6 of the *Manual of Uniform Traffic Control Devices for Canada* (cited in Part A), must meet the applicable specifications in article A1.6 of that Manual, and must provide warning:

(a) in advance of the delayed activation of the flashing lights of the warning system in order for a vehicle travelling at the road design speed to pass the Prepare to Stop at Railway Crossing sign that is not activated and to:

(i) clear the grade crossing in advance of the arrival of railway equipment where there is a warning system without gates; or

(ii) clear the grade crossing before the start of the descent of the gate arms where there is a warning system with gates; and

(b) during the time of the operation of the flashing lights of the warning system;

18.2 Where Prepare to Stop at Railway Crossing signs are utilized, 4 hours continuous battery back-up power must be provided for all interconnected devices

19 PRE-EMPTION OF TRAFFIC SIGNALS BY WARNING SYSTEMS

19.1 Pre-emption is to be provided at grade crossings where the railway design speed is 25 km/h (15 mph) or more and where the grade crossing meets the following specifications:

a) there is less than 30 m between the stop line for the traffic signals and the rail nearest the road intersection and the operation of traffic signals on a road approach to a grade crossing equipped with a warning system or,

b) there is 30 m or greater between the stop line for the traffic signals and the rail nearest the road intersection and a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface.

19.2 Except as otherwise specified in these standards or in the *Grade Crossings Regulations*, the pre-emption of traffic signal operation by a warning system and installation of traffic signals upstream of the grade crossing in accordance with article 19.1 must be designed and operate in accordance with Part 3 of the *AREMA Communications and Signals Manual* (cited in Part A).

19.3 The pre-emption of traffic signal operation by a warning system must:

(a) provide sufficient time to clear the grade crossing of road traffic before the arrival of railway equipment at the grade crossing;

(b) prevent movement of road traffic from the intersection towards the grade crossing.

19.4 Where traffic signals are interconnected by warning systems, 4 hours continuous battery back-up power must be provided for all interconnected devices.

19.5 In the case of 19.1(b), a traffic control device that activates when queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface may be installed to warn drivers not to enter or prevent them from entering the crossing instead of the pre-emption system referred to in 19.1.

20 INTERCONNECTED DEVICES - INSPECTION AND TESTING

Table 20-1– Required Frequencies of Inspections and Tests for Prepare to Stop at Railway Crossing Signs or a Traffic Signal Pre-emption

COLUMN 1	***COLUMN 2***	***COLUMN 3***
ITEM	***Components and Inspection and Testing requirements***	***Frequency***
1	Prepare to Stop at Railway Crossing sign: for visibility of light units	Annually
2	Traffic Signals installed at a grade crossing in lieu of a warning system: for cleanliness, visibility of signal heads, and physical damage	Annually
3	Traffic signal: for pre-emption by warning systems	Annually
4	Prepare to Stop at Railway Crossing Sign: for activation and operation	Annually

APPENDIX A – LIGHT EMITTING DIODE (LED) SIGNAL MODULES

Standards for LED Signal Modules in Warning Systems

1 DEFINITIONS

Candela (cd) – SI unit of luminous intensity. The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 nm and that has a radiant intensity in that direction of 1/683 W per steradian (1 cd = 1 lm/sr).

Lumen (lm) – SI unit of luminous flux. Luminous flux emitted in unit solid angle [steradian (sr)] by a uniform point source having a luminous intensity of 1 candela (1 lm = 1 cd x 1 sr).

Luminance L_v (in a given direction, at a given point on a real or imaginary surface) – quantity defined by the formula:

$$L_v = \frac{d\Phi_v}{dA \cdot d\Omega \cdot \cos\theta}$$

where $d\Phi_v$ is the luminous flux transmitted by an elementary beam passing through the given point and propagating in the solid angle dΩ containing the given direction; dA is the area of a section of that beam containing the given point; θ is the angle between the normal to that section and the direction of the beam (footlambert, cd/m^2).

Luminous Efficacy of Radiation (K) – the luminous flux Φ_v divided by the corresponding radiant flux Φ_e ($K = \Phi_v/\Phi_e$).

Luminous Intensity (I_v) (of a source in a given direction) – the luminous flux $d\Phi_v$ leaving the source and propagating in the element of solid angle dΩ containing the given direction, divided by the element of solid angle ($I_v = d\Phi_v / d\Omega$ candela).

Luminous Flux (Φ_v) – quantity derived from radiant flux Φ_e by evaluating the radiation according to its action upon the CIE standard photometric observer (lumen).

Rated Voltage – the nominal or design operating voltage of the LED signal module; the voltage at which rated watts, candelas, and life are determined.

Rated Watts – the average initial power (watts) consumed when the lamp is operated at rated voltage.

2 PHOTOMETRIC REQUIREMENTS

2.1 Luminous Intensity

When LED signal modules are in use at a warning system, they must at all times and under all normal operational conditions meet the minimum luminous intensity values shown in Table A-1.

Table A-1 – Minimum Luminous Intensity (Candela) over Temperature and Lifetime

	0˚	**5˚Left (L)/Right (R)**	**10˚L/R**	**15˚L/R**	**20˚L/R**	**25˚L/R**	**30˚L/R**
0˚	400	375	250	150	75	40	15
5˚Down (D)	350	325	250	150	75	40	15
10˚D	130	125	110	85	60	35	15
15˚D	45	40	35	30	25	20	15
20˚D	15	15	15	15	15	15	10

2.2 Chromaticity

A signal module must produce a uniform red light output as specified in article 4.2 of the *Vehicle Traffic Control Signal Heads – Light Emitting Diode Circular Supplement,* published by the *Institute of Transportation Engineers,* dated June 2005.

2.3 Uniformity

The ratio of the greatest and least luminance on the signal module must not be more than 5:1, when measured over average areas of 500 mm^2.

2.4 Rise/Fall Time

The maximum rise time from zero intensity to full intensity, and the maximum fall time from full intensity to zero intensity, must be 75 ms.

3 PHYSICAL AND MECHANICAL REQUIREMENTS

3.1 LED Signal Module Design

3.1.1 The LED signal module must be designed to fit the grade crossing light unit housings, described in Part 3.2.35 of the *AREMA Communications and Signals Manual* (cited in Part A), without requiring modification of the mechanical, structural, or electrical components.

3.1.2 The LED signal module must be either 200 mm or 300 mm in size.

3.1.3 The LED signal module must have either a clear or a red lens.

3.1.4 Any gasket or similar sealing provisions must be made of a material as specified in Part 15.2.10 of the *AREMA Communications and Signals Manual* (cited in Part A).

3.2 Environmental Requirements

3.2.1 The LED signal module must operate over an ambient temperature range of -40°C (-40°F) to 70°C (158°F) in accordance with "Method 1010.8 Temperature Cycling", dated June 18, 2004 of MIL-STD-883H, *Test Method Standard, Microcircuits*, published by the United States Department of Defence, dated February 26, 2010 and must satisfy the failure criteria set-out in article 3.3 of that standard, except that any reference to article 4 of that standard may be disregarded.

3.2.2 The LED signal module must be protected against dust and moisture intrusion in a Type 4 enclosure in a manner that meets the requirement of article 8.6.2 of the Canadian Standards Association standard CAN/CSA-C22.2 No. 94.2-07 entitled *Enclosures for Electrical Equipment, Environmental Considerations*, as amended from time to time, when tested in accordance with article 8.6.1 of that Standard.

3.2.3 The LED signal module must be meet mechanical vibration and shock requirements as specified in Part 11.5.1 of the *AREMA Communications and Signals Manual* (cited in Part A).

3.2.4 The LED signal module lens must be UV stabilized.

3.3 Identification

3.3.1 The LED signal module must have a label containing the following information:

a) the LED colour;

b) the beam deflection classification;

c) the operating voltage;

d) the current consumption at operating voltage;

e) Certification that the module meets Transport Canada Appendix A of the *Grade Crossings Standards*;

f) the module's serial number; and

g) the date of manufacture.

3.3.2 If the module or its components require orientation, they must be prominently and permanently marked with an indexing arrow.

4 ELECTRICAL REQUIREMENTS

4.1 Transient Voltage Protection

LED signal module circuitry must include voltage surge protection as specified in Part 11.3.3 of *AREMA Communications and Signals Manual* (cited in Part A).

4.2 LED Drive Circuitry

LED signal module circuitry must operate as specified in Part 3.2.35 of the *AREMA Communications and Signals Manual* (cited in Part A).

4.3 Dielectric and Electromagnetic Interference

LED signal module circuitry must conform to dielectric and electromagnetic interference requirements for Class B equipment in Part 11.5.1 of *AREMA Communications and Signals Manual* (cited in Part A).

APPENDIX B - LIMITED USE WARNING SYSTEMS

1 Operating Requirements

1.1 Battery backup for a minimum of 24 hours of normal railway operations must be provided.

1.2 Power monitor lights must be provided.

2 Warning System Requirements

2.1 Warning System does not require gates.

2.2 Height of the light unit may be different than the *AREMA Communications and Signals Manual* (cited in Part A) or the *GCS* (cited in Part A) as to improve conspicuity.

2.3 Signal mast may be located closer to the road approach than the *AREMA Communications and Signals Manual* (cited in Part A) or the *GCS* (cited in Part A) so as to improve conspicuity.

2.4 Warning System does not require a bell or other audible device.

2.5 Warning time must be calculated as specified in article 16.1 of the *GCS* (cited in Part A).

2.6 Warning signal assemblies must be as specified in article 12.2, except as specified in articles 2.1 to 2.4.

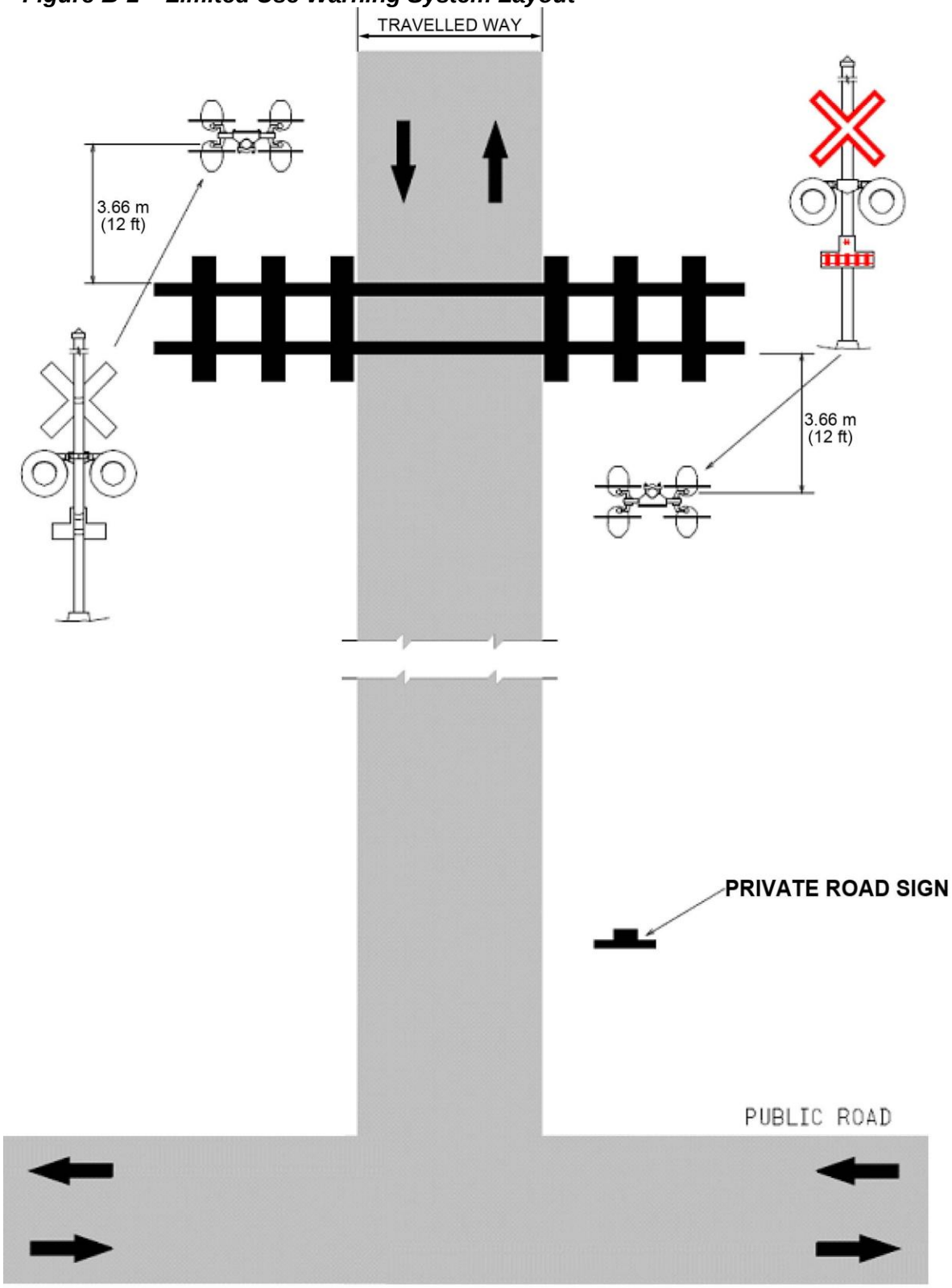
2.7 Front and back lights must be provided on each warning signal assembly

3 Signage Requirements

3.1 An Emergency Notification sign must be located at each installation.

3.2 A sign indicating that the road approach is private must be posted at appropriate road approaches to the crossing as indicated in Figure B-1.

Figure B-1 – Limited Use Warning System Layout



APPENDIX C - LIMITED USE WARNING SYSTEMS WITH WALK LIGHT

1 WALK LIGHT DESIGN

General

1.1 Limited Use Warning Systems with walk light installations must be designed and installed in accordance with Figures C-1, C-2 and C-3.

Operating Requirements

1.2 Battery backup of a minimum of 8 hours of normal railway operations must be provided.

1.3 Power monitor lights must be provided.

Signal Requirements

1.4 A signal installation as described below must be located at each road approach to the crossing.

1.5 The Limited Use Warning Systems with walk light installations must include a signal head capable of displaying a “Safe to Proceed (Walking Person)” indication when railway equipment is not approaching. This must be extinguished when railway equipment is approaching.

1.6 The signal head must be as specified in sections 2 to 5 of the ITE “*Pedestrian Traffic Control Signal Indications - Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules*” prepared by the Joint Industry and Traffic Engineering Council Committee, published by the Institute of Transportation Engineers, dated March 19, 2004, except for the following aspects:

a) Utilizes 12VDC pedestrian module instead 120VAC input voltage,

b) Operating voltage range is 9 – 15VDC with the unit shutting off at 7.3VDC,

c) Module does not comply with the AC Harmonics and Power Factor portions of ITE which are based on the 120VAC input voltage,

d) References to “LED Pedestrian Signal Module” or “Module” are to be read as “walk light”, and

e) The last paragraph under article 4.1.1 is to be disregarded.

1.7 The proceed signal must be extinguished a minimum of 20 seconds plus clearance time before the arrival of railway equipment.

1.8 Clearance time must be based on design vehicle and must be calculated in accordance with the requirements of the *GCS* (cited in Part A).

Signage and Post Requirements

1.9 The signal installation must be mounted on either a metal pole or wooden post.

1.10 Signage indicating how to use the Limited Use Warning Systems with walk light as illustrated in Figure C-3 must be posted on the installation post under the walk light signal head as indicated in Figure C-2. Where required by law, the word “Arrêt” will replace the word “Stop”, or may be added to the Stop Sign.

1.11 A Stop sign, as shown in the *Manual of Uniform Traffic Control Devices for Canada* (cited in Part A) must meet the applicable specifications A1.6 of that Manual and must be posted on the installation post as indicated in Figure C-2.

1.12 An Emergency Notification sign must be located at each Limited Use Warning Systems with walk light installation.

1.13 A sign indicating that the road approach is private must be posted at each road approach to the crossing.

1.14 The sign as shown in Figure C-3 must be affixed to the mast of the Limited Use Warning Systems with walk light as shown in Figure C-2. The sign must have a silver background that is reflective with silk screened black or vinyl lettering.

Figure C-1 – Limited Use Warning System with Walk Light Layout

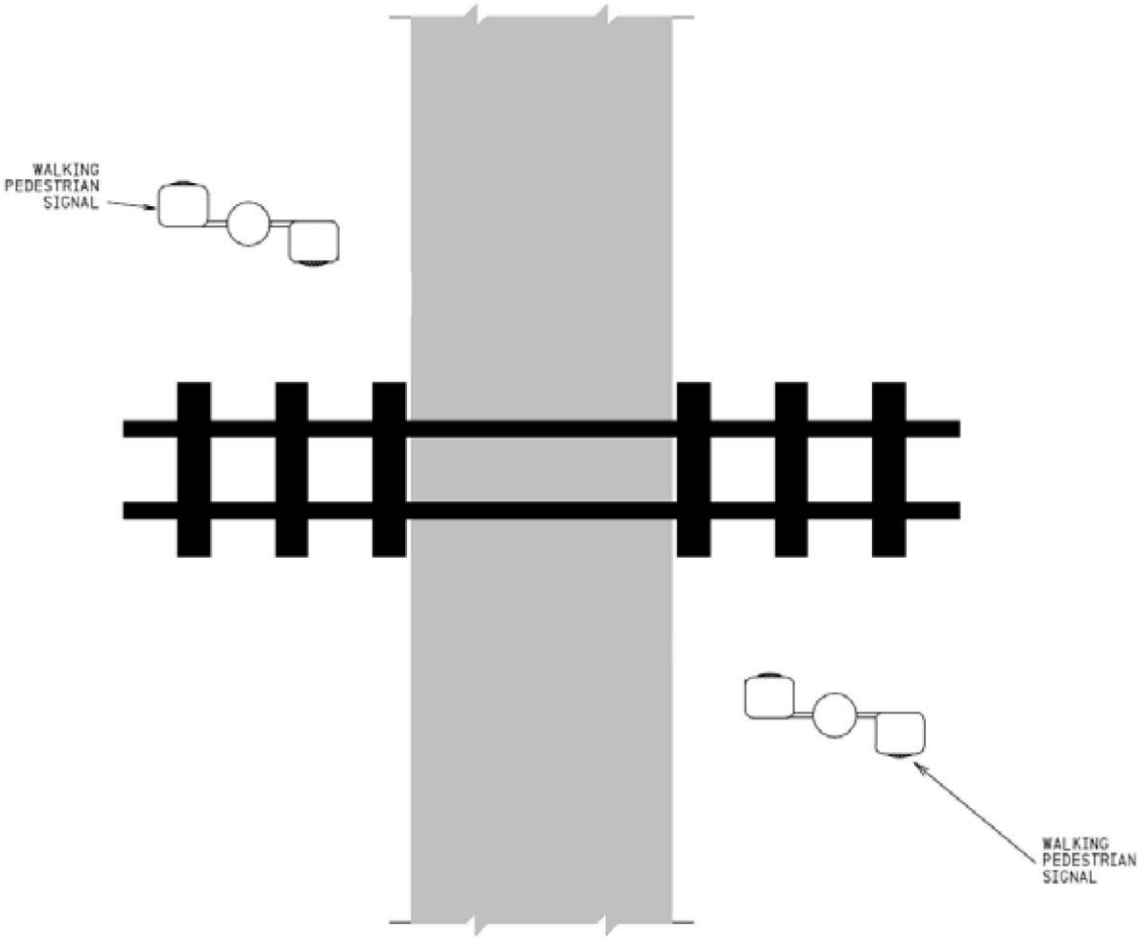


Figure C-2 – Limited Use Warning System with Walk Light Assembly

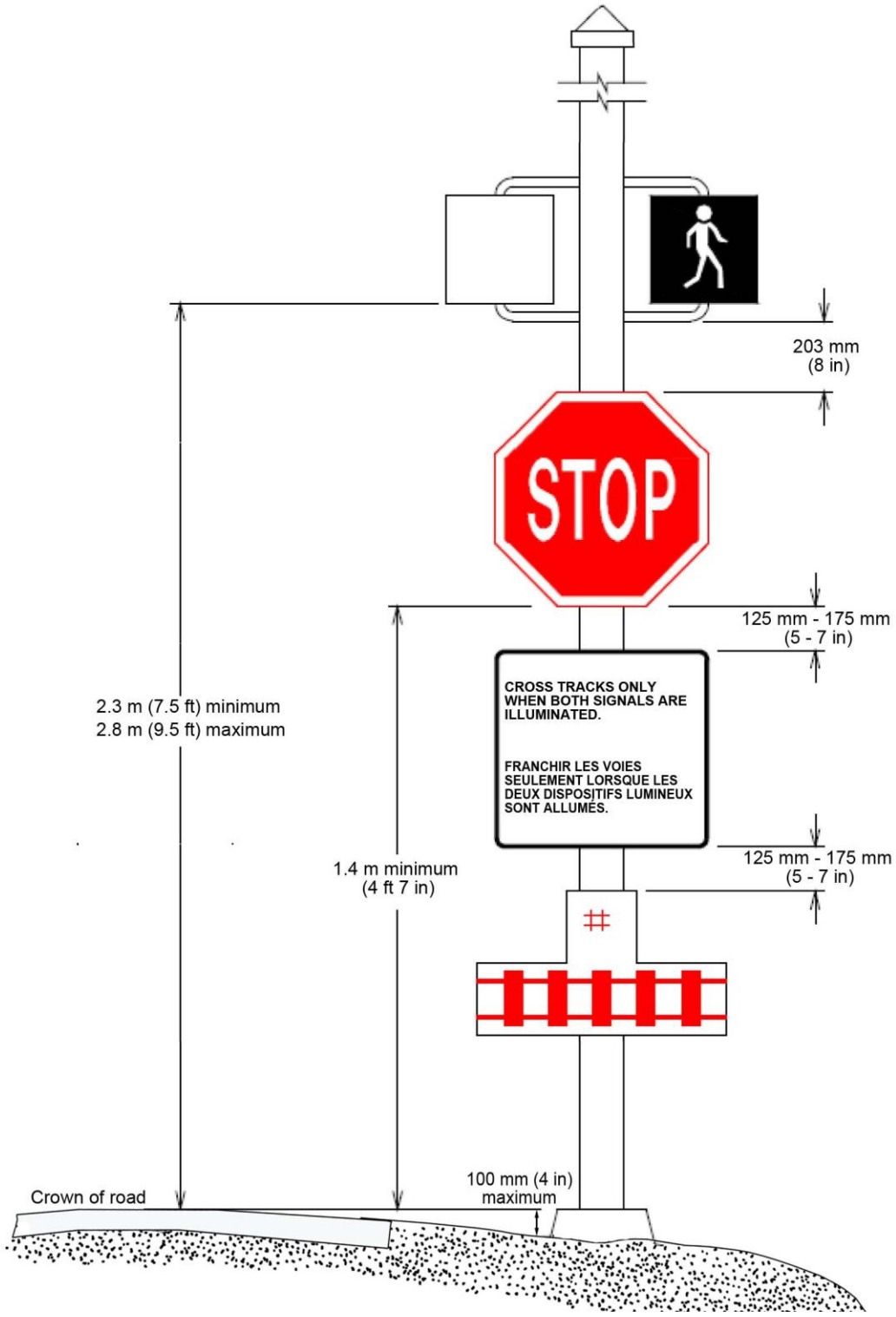
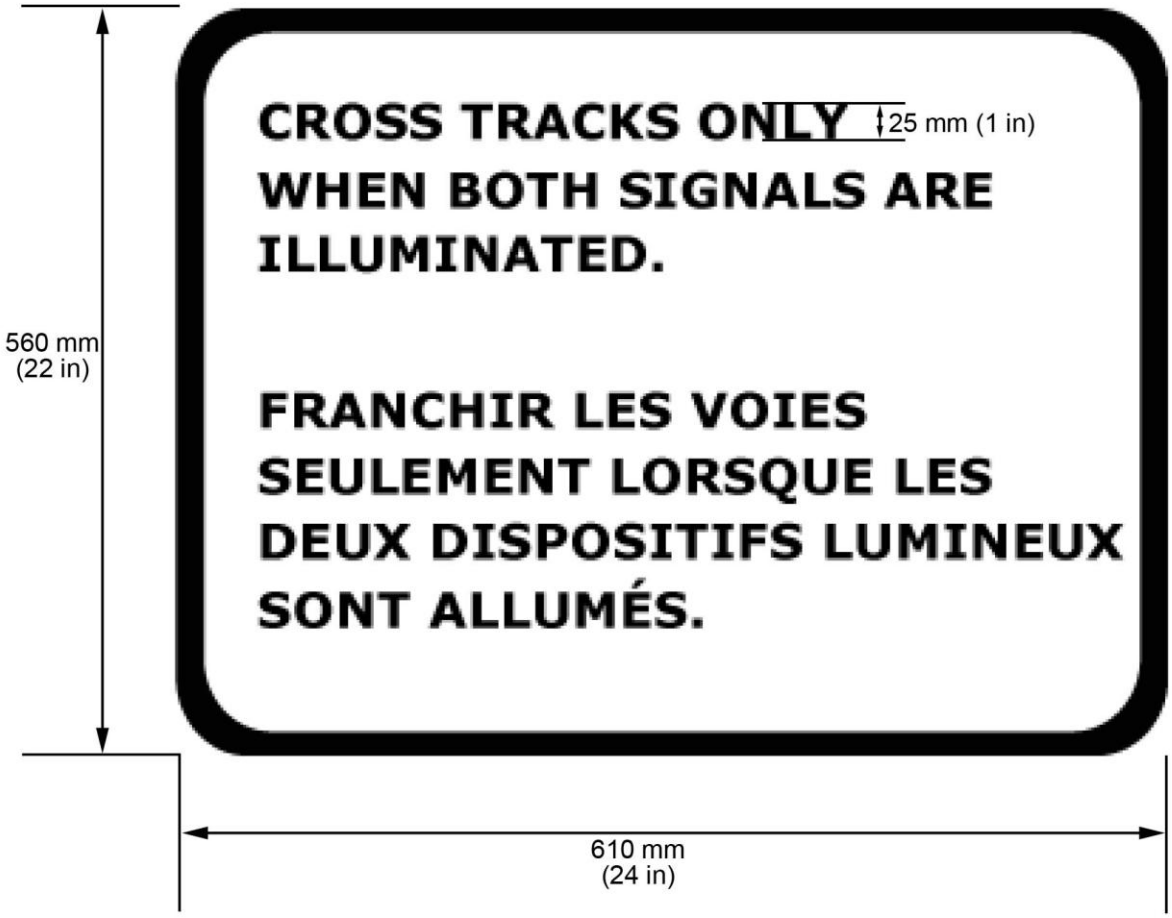


Figure C-3 – Instruction Sign



APPENDIX D – WHISTLING CESSATION

Table D-1 – Requirements for Warning Systems at Public Grade Crossings within an Area without Whistling

Railway Design Speed	Grade Crossings for Vehicle Use		Grade Crossings Exclusively for Sidewalks, Paths, or Trails with the centreline no closer than 3.6 m (12 ft) to a warning signal for vehicles	
	No. of Tracks		No. of Tracks	
	1	2 or more	1	2 or more
Column 1	***Column 2***	***Column 3***	***Column 4***	***Column 5***
Up to 25 km/h (15 mph)	FLB	** FLB	No requirement	* No warning system requirements
25 – 81 km/h (16 – 50 mph)	*** FLB	FLB & G	**** FLB	FLB & G
Over 81 km/h (50 mph)	FLB & G	FLB & G	FLB & G	FLB & G

** see article 2.3 below*

*** see article 1.1 below*

**** see article 1.2 below*

***** see article 2.2 below*

Legend :

FLB is a grade crossing warning system consisting of flashing lights and a bell.

FLB & G is a grade crossing warning system consisting of flashing lights, gates, and a bell.

1 Specifications for grade crossings with warning systems

1.1 Where the railway design speed is 25 km/h (15 mph) or less if there is a possibility of two trains approaching on the operating control circuits of the grade crossing warning system at the same time.

1.2 In addition to flashing lights and bells set-out in Table D-1, a warning system must be equipped with gates if one of the following applies:

(a) the forecast cross-product is 50,000 or more; or

(b) the railway design speed is more than 81 km/h (50 mph); or

(c) there are two or more lines of railway where railway equipment may be passing one another; or

(d) it is a public grade crossing where the railway design speed is more than 25 km/h (15 mph), and the distance between the front of a vehicle stopped at a Stop Sign or traffic signal on the departure lane of a grade crossing, and the nearest rail in the crossing surface is:

(i) less than 30 m for a Stop Sign or less than 60 m for traffic signals; or

(ii) 30 m or more for a Stop Sign, or 60 m or more for traffic signals, if a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface, as shown in Figure 9-1; or

(e) it is a public grade crossing where the railway design speed is more than 25 km/h (15 mph) and a traffic study conducted by the road authority indicates that queued traffic regularly stops within 2.4 m of the nearest rail in the crossing surface.

1.3 For a public grade crossing that is for vehicular use and that has a sidewalk, path or trail within 3.6 m (12 ft) of the travelled way of the crossing surface; the warning system specified in Table D-1 must be equipped with gates at the sidewalk, path or trail, if railway design speeds are more than 129 km/h (80 mph).

2 Other protection

2.1 For a grade crossing that is for vehicle use, and where railway equipment is required to stop before proceeding over the grade crossing:

(a) a warning system with flashing lights and bells must be in place; or

(b) a crew member must be present to stop vehicles before permitting the railway equipment to proceed over the grade crossing.

2.2 For a public grade crossing for sidewalks, paths, or trails as referred to in Table D-1, guide fencing must be in place to deter persons from crossing the line of railway other than at the grade crossing.

2.3 Barriers must be in place in addition to the guide fencing referred to in article 2.2 at a public grade crossing:

(a) that is for a sidewalk, path or trail;

(b) that includes two or more tracks; and

(c) for which the railway design speed is 25 km/h (15 mph) or less, and does not include a stop and proceed for railway equipment.

Figure D-1 – prescribed area for whistling cessation as per article 23.1 of the RSA