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Rail Safety

Oversight and Expertise

Determining Minimum Sightlines at Grade Crossings:

A Guide for Road Authorities and Railway Companies

Canada

Cette publication est aussi disponible en français sous le titre Guide servant à déterminer les lignes de visibilité minimales aux passages à niveau à l'intention des autorités responsables du service de voirie et des compagnies de chemin de fer.

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Guide for Determining Minimum Sightlines at Grade Crossings

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Guide for Determining Minimum Sightlines at Grade Crossings

Part One: Overview

1.1 Purpose

This Guide contains advice and technical guidance that stakeholders (road authorities, private authorities and railway companies) need to determine the minimum sightlines required at grade crossings.

The *Grade Crossings Regulations* (GCR) and Grade Crossings Standards (GCS) were introduced on November 27, 2014. They require road authorities and railways to establish and maintain sightlines at grade crossings. These sightlines must, at minimum, provide crossing users with enough time to see and react to an oncoming train, from both the 'approach' and 'stop' positions.

This Guide replaces the *Minimum Railway/Road Crossing Sightline Requirements for All Grade Crossings without Automatic Warning Devices G4-A*. While you may still use the G4-A guideline as a quick reference guide, the sightline requirements in this Guide are based on the new *Grade Crossings Regulations* and Grade Crossings Standards, so are more accurate, flexible and descriptive.

In addition to this Guide, you should have a thorough knowledge of the key documents that specify the design guidelines and standards for grade crossings, including:

- the GCS;
- the *Geometric Design Guide for Canadian Roads* by the Transportation Association of Canada (TAC); and
- TAC's *Manual of Uniform Traffic Control Devices for Canada.*

1.2 A Phased-in Approach

The *Grade Crossings Regulations* use a phased-in approach over seven years that gives you planning flexibility. Sightline requirements in the GCR and GCS must be in place at:

- all **new crossings** when they are built or significantly altered (see GCR, section 20), and
- ALL other crossings by November 27, 2021.

1.3 Application

The minimum sightline requirements set out in GCR sections 20, 21 and 22; and in GCS, article 7; enable grade crossing users to safely see and react to an oncoming train. These requirements **apply to all public and private grade crossings**.

For the purpose of defining sightlines, every crossing has four quadrants created by the angle formed by the intersection of the road and the track. You must determine minimum sightlines for **all four quadrants** of the crossing so crossing users can see an oncoming train from both road approach directions while they are in the 'approach' and the 'stop' positions. For increased safety, Transport Canada strongly encourages you to provide sightlines **above and beyond** the minimum requirements we identify in this guide.

In addition to establishing unobstructed sightlines, you must:

- keep sightlines clear of trees, brush and stored materials to protect the visibility of the grade crossing, railway crossing warning signs, signals, and approaching trains; and
- ensure that highway traffic signs, utility poles and other roadside installations do not obstruct the view of railway crossing signs, signals and warning systems.

1.4 Variables to Consider

In some cases, we recommend increasing minimum sightlines to account for factors affecting the acceleration or deceleration of vehicles using the road. Such factors include road gradient and surface condition as well as vehicle weight, length and power.

You must also consider important variables such as:

- road gradient;
- use of heavy or long combination vehicles (LCV's) on truck routes;
- designated over-dimensional load routes;
- industrial park roads; and
- farm crossings .

Take sightlines for drivers stopped at a grade crossing from a position no closer than 5 metres from the nearest rail, measured from the driver's position in the vehicle. The minimum time a driver must see a train before it arrives at a grade crossing is generally 10 seconds, although some vehicle types may need more time.

Note: If the road design speed or the railway design speed varies on either side of the grade crossing, you must make stand-alone calculations for each quadrant.

1.5 Collaboration of Authorities

The GCR encourage railway companies and road authorities to work together to meet sightline requirements. For example:

- **The railway company** can provide the road authority with maximum permissible train speeds and volumes.
- **The road authority** can advise on maximum and operating roadway speeds and either know, or can determine, the types/classifications of vehicles using public highways.

Since both the railway company and road authority are responsible for providing and maintaining adequate sightlines for their infrastructure, it is very important that both:

- are aware of all factors affecting sightlines; and
- remain involved.

1.6 Flexible Options

The GCR provide flexibility for determining sightlines and can be adapted to the unique physical and operational attributes of each crossing. For example, for crossings without a grade crossing warning system, you can achieve minimum sightlines by clearing sightline obstructions, or reducing train or vehicle speeds. In some cases you can restrict the use of heavy or long combination vehicles, or improve road approach gradients. Other options may include installing a STOP sign or Active Warning System.

- Requirements for sightlines at grade crossings **without** a grade crossing warning system are specified in GCR subsections 20(2) and 21(1), which refer to GCS figures 7-1 (a) and (b).
- Requirements for sightlines at grade crossings **with** a grade crossing warning system are specified in subsections 20(1) and 21(2), which refer only to GCS figure 7-1 (a).

1.7 Exceptions to the Requirements:

Sightline requirements vary depending on the safety attributes at the grade crossing:

- Public or Private grade crossing with a Warning System with Gates: sightline requirements do not apply but the warning system must be visible throughout the Stopping Sight Distance (SSD).
- Public or Private grade crossing with STOP sign or Warning System: sightlines are required from the stopped position only, as shown in Figure 3 from section 2.2.2 of this Guide. The STOP sign and Warning System must be visible throughout the SSD.
- Private grade crossing where the railway design speed is 25 km/h (15 mph) or less and access to the road leading to the grade crossing is controlled by a locked barrier, or the grade crossing is for the exclusive use of the private authority and is not used by the public: sightline requirements do not apply (however, it is strongly encouraged to provide sightlines at all times); and
- Public or private grade crossing being operated under **Manual Protection** (where the road users are stopped by a flag person and the railway equipment must STOP and Proceed at the crossing): sightline requirements are limited to visibility of the grade crossing within the SSD.

Part Two: Calculating Sightlines

If the road design speed or the railway design speed varies on either side of the grade crossing, you must do stand-alone calculations for each quadrant.

2.1 What You Need to Know:

To establish the minimum sightlines for each quadrant of any grade crossing you must first determine six key factors. Doing this in advance will make the sightline calculation process easier.

Factor 1: Design vehicle and its dimensions

A 'design vehicle' is the most restrictive vehicle that authorities expect to regularly use the grade crossing:

- The road authority chooses the design vehicle for a public grade crossing.
- The railway company chooses the design vehicle for a private grade crossing.

There are three classes of design vehicle: 1) Passenger Cars; 2) Single Unit Trucks and Buses; and 3) Tractor-Semitrailers. Longer or larger vehicles usually generate a larger clear sightline triangle.
See Table 1 below for vehicle descriptions.

Note: There are also four categories of Special Vehicles included in the TAC Geometric Design Guide including: Long Load Vehicles, Long Combination Vehicles, Towed Recreational Vehicles, Large Trucks with Tandem or Triple Steering Axle.

Design Vehicle Length (L):_________ (m)
Design Vehicle Class: _______________

Factor 2: Road Crossing Design Speed

The 'road crossing design speed' is the motor vehicle speed that corresponds to the grade crossing's current design:

- The road authority chooses the road crossing design speed for public grade crossings.
- The railway company chooses the road crossing design speed for private grade crossings.

Road Crossing Design Speed (V): ________________ (km/h)

Factor 3: Railway Design Speed

The 'railway design speed' is the railway equipment speed that corresponds to the grade crossing's current design. The railway company chooses the railway design speed.

Railway Design Speed (V_t): ________________ (mph)

Table 1 – Design vehicle Lengths/Class

General Vehicle Descriptions	Length (m)	Design Vehicle Class
1. Passenger Cars, Vans and Pickups (P)	5.6	Passenger Car
2. Light Single-unit Trucks (LSU)	6.4	Truck
3. Medium Single-unit Trucks (MSU)	10.0	Truck
4. Heavy Single-unit Trucks (HSU)	11.5	Truck
5. WB-19 Tractor-Semitrailers (WB-19)	20.7	Truck
6. WB-20 Tractor-Semitrailers (WB-20)	22.7	Truck
7. A-Train Doubles (ATD)	24.5	Truck
8. B-Train Doubles (BTD)	25.0	Truck
9. Standard Single-Unit Buses (B-12)	12.2	Bus
10. Articulated Buses (A-BUS)	18.3	Bus
11. Intercity Buses (I-BUS)	14.0	Bus

Source: *Geometric Design Guide for Canadian Roads*, TAC; September 1999.

Factor 4: Road Approach Gradient

The 'road approach gradient' is the average gradient over the Stopping Sight Distance (SSD). The road authority determines the road approach gradient.

Road Approach Gradient: _______________ (%)

Factor 5: Stopping Sight Distance - (Tables 2 and 3)

The Stopping Sight Distance (SSD) is the minimum sight distance required along the road approach for a crossing user to react to approaching railway equipment. The SSD is based on the road crossing design speed:

- Use Table 2 to determine the SSD for Passenger Car Class
- Use Table 3 to determine the SSD for Truck Class.

Table 2 – Determine SSD for Passenger Car Class

Road Crossing Design Speed V (km/hr)	Passenger Car Class Stopping Sight Distance (SSD) (m)																				
	Road Approach Gradient																				
	-10%	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
20	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20	20	19	19	19	19	19
30	33	33	32	32	32	31	31	31	30	30	30	30	30	29	29	29	29	29	29	28	28
40	51	50	49	49	48	48	47	46	46	45	45	45	44	44	43	43	43	42	42	42	42
50	76	75	73	72	71	70	69	68	67	66	65	64	63	63	62	61	61	60	60	59	59
60	104	101	99	97	95	93	91	89	88	86	85	84	83	81	80	79	78	77	77	76	75
70	140	135	132	128	125	122	119	117	114	112	110	108	106	105	103	101	100	99	97	96	95
80	182	176	171	166	161	157	153	149	146	143	140	137	135	132	130	128	126	124	122	121	119
90	223	216	209	202	197	191	186	182	178	174	170	167	163	160	157	155	152	150	148	145	143
100	281	271	262	253	245	238	232	226	220	215	210	205	201	197	194	190	187	184	181	178	175
110	345	331	318	307	296	287	278	270	263	256	250	244	239	234	229	224	220	216	307	209	205

Table 3 – Determine SSD for Truck Class

Road Crossing Design Speed V (km/hr)	Truck Class Stopping Sight Distance (SSD) (m)																				
	Road Approach Gradient																				
	-10%	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
20	26	26	26	26	26	26	25	25	25	25	25	25	25	25	25	25	24	24	24	24	24
30	48	48	47	47	47	46	46	46	45	45	45	45	45	44	44	44	44	44	44	43	43
40	76	75	74	74	73	73	72	71	71	70	70	70	69	69	68	68	68	67	67	67	67
50	121	120	118	117	116	115	114	113	112	111	110	109	108	108	107	106	106	105	105	104	104
60	149	146	144	142	140	138	136	134	133	131	130	129	128	126	125	124	123	122	122	121	120
70	210	205	202	198	195	192	189	187	184	182	180	178	176	175	173	171	170	169	167	166	165
80	252	246	241	236	231	227	223	219	216	213	210	207	205	202	200	198	196	194	192	191	189
90	318	311	304	297	292	286	281	277	273	269	265	262	258	255	252	250	247	245	243	240	238
100	401	391	382	373	365	358	352	346	340	335	330	325	321	317	314	310	307	304	301	298	295
110	455	441	428	417	406	397	388	380	373	366	360	354	349	344	339	334	330	326	322	319	315

Stopping Sight Distance (SSD):___________________ (m)

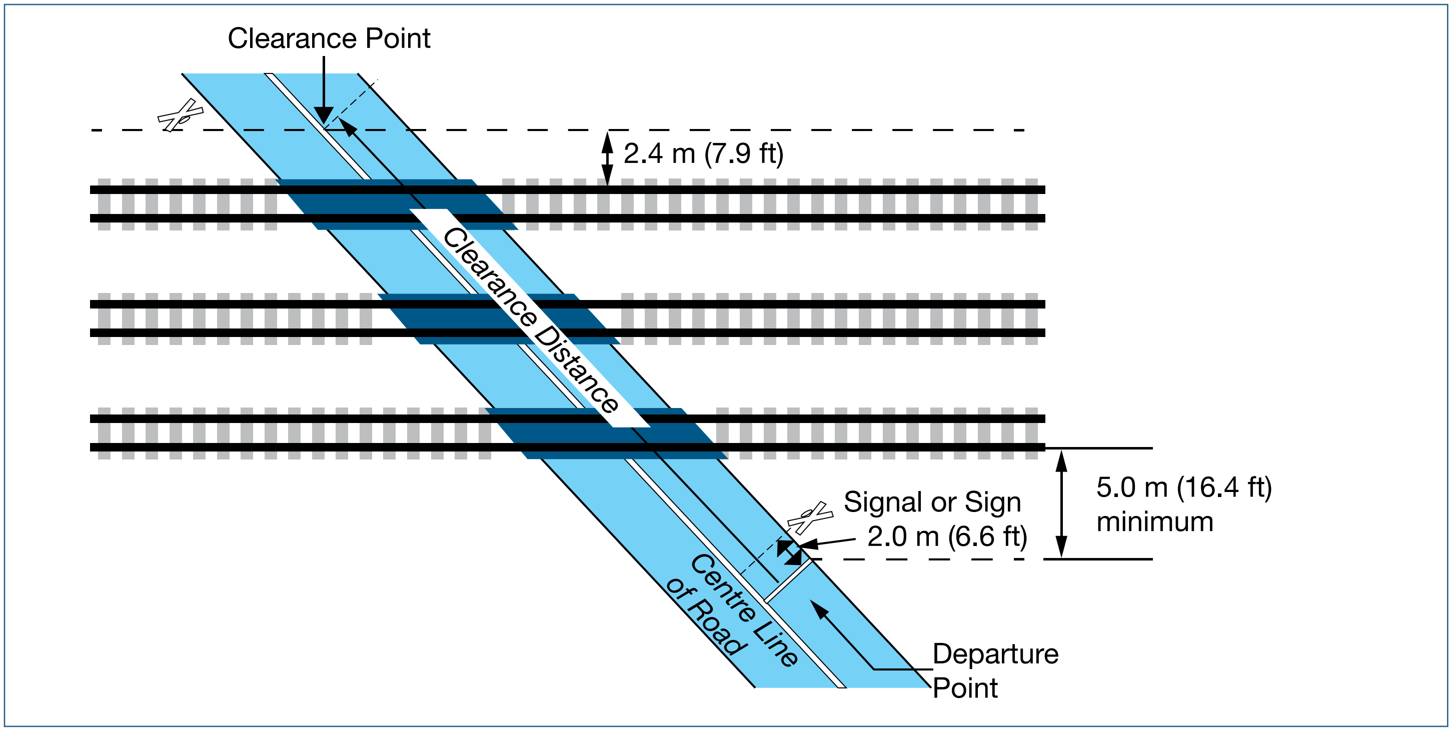
Factor 6: Grade Crossing Clearance Distance

The 'grade crossing clearance distance' is the distance between the departure point before crossing the tracks, to the clearance point on the other side, away from the conflict zone.

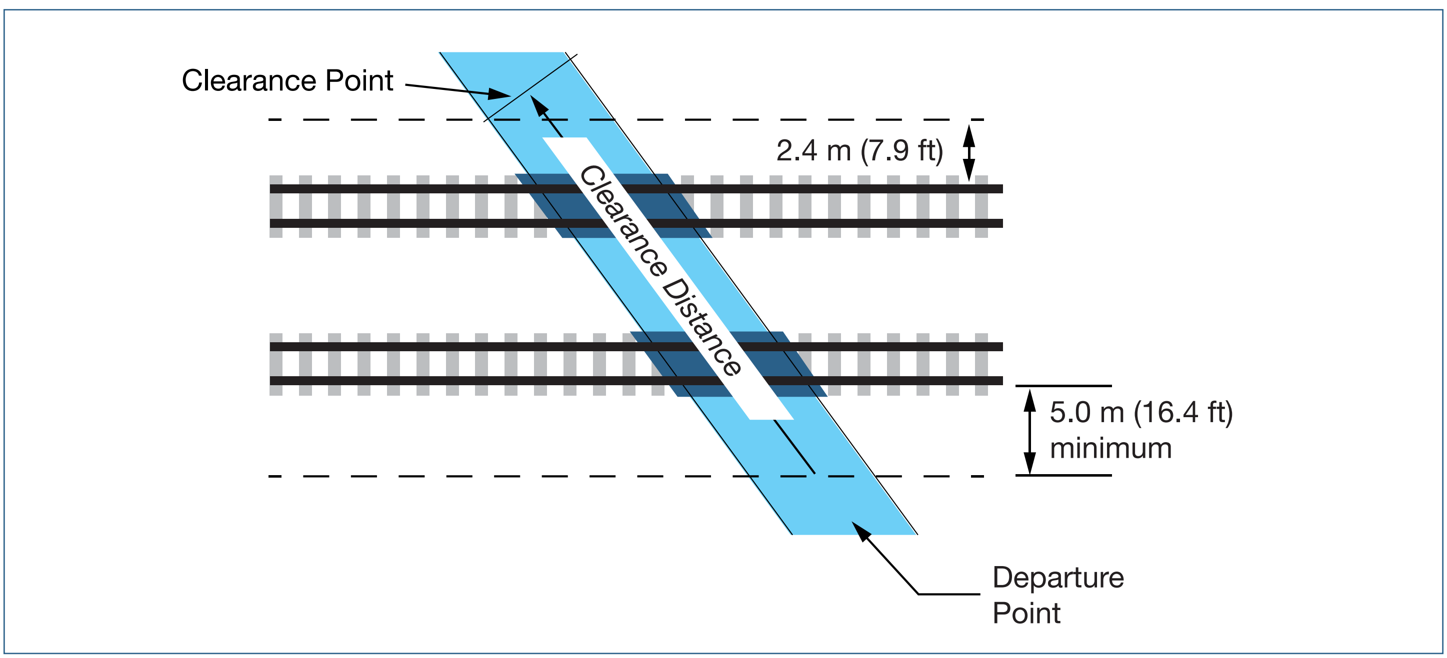
Once onsite, or from plans, estimate the grade crossing clearance distance as shown in Figures 1(a) and 1(b)

Figure 1 – Grade Crossing Clearance Distance Crossing

(a) For Grade Crossings with a Warning System or Railway Crossing Sign



(b) For Grade Crossing without a Warning System or Railway Crossing Sign



Grade Crossing Clearance Distance (cd) : __________ (m)

Once you have determined the six key factors above you can begin to calculate the minimum required grade crossing sightlines as described in section 2.2 below.

2.2 How to Calculate Sightlines

The following process to calculate sightlines in accordance with the *Grade Crossings Regulations* applies to **all** grade crossings:

- new or existing,
- public or private,
- after or before 7 years,
- with or without a grade crossing warning system.

Exceptions to these requirements are listed in section 1.7 above.

To satisfy the GCR, you must use the 6 key factors determined above, to calculate the minimum required sightlines for both the SSD approach point and the stopped position.

Determining minimum sightlines from the SSD approach point is a two-step process. The values determined in Steps 1 and 2, described below, define the minimum clear sightline area required for the SSD approach position, as indicated in Figure 2 above. This value may be different for each road approach. Although Figure 2 illustrates only one quadrant, in the field, you must verify the clear sightline area for all four quadrants (i.e. to the right and left sides of each road approach).

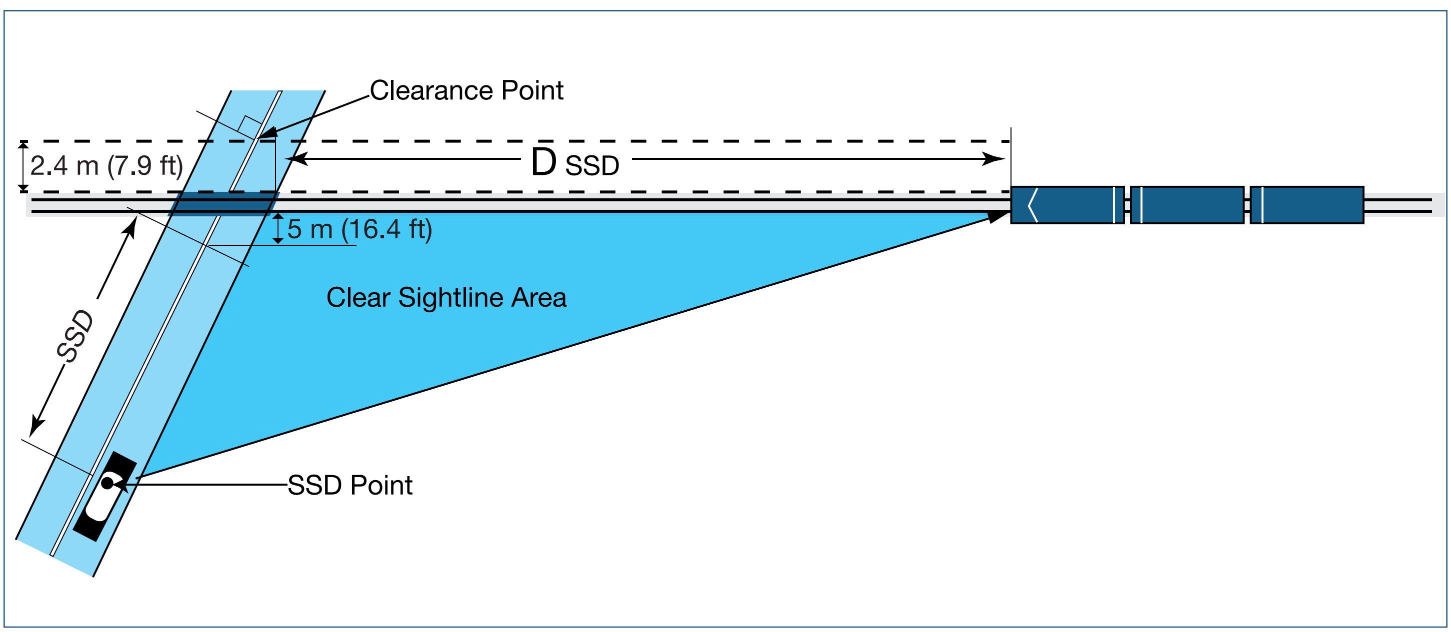
2.2.1 Determining Sightlines from the SSD Approach Point

The SSD is the **minimum** sight distance along the road approach that a crossing user needs to react to approaching railway equipment. The SSD is based on the road crossing design speed. The method to determine SSD is described in Factor 5 of Section 2.1 of this document.

D_{SSD} is the **minimum** distance along the line of railway (in both directions) that a crossing user needs to see approaching railway equipment from the SSD point.

D_{SSD} is equal to the distance the design vehicle must go from the SSD point completely past the clearance point on the other side of the grade crossing, at its road crossing design speed.

Figure 2 – Minimum Sightlines for Drivers Approaching a Grade Crossing



Step 1

Calculate the Minimum Stopping Sight Distance Time (T_{SSD}) for each road approach to the grade crossing using the formula below.

Formula: $T_{SSD} = [(SSD + cd + L) / (0.278 \times V)]$

Where :

V = road crossing design speed (km/h)

cd = grade crossing clearance distance (m)

L = length of grade crossing design vehicle (m)

SSD = stopping sight distance from Tables 2 and 3 based on the design vehicle class (m)

Road approach 1 T_{SSD} = __________ (s)
Road approach 2 T_{SSD} = __________ (s)

Step 2

Calculate the Minimum Sightlines along the Rail Line (D_{SSD}) for each road approach using Table 4 OR the formula indicated below Table 4.

Note: To use Table 4, you must:

1. Calculate the T_{SSD} (see Step 1) for the design vehicle required for the grade crossing, and to determine the railway design speed (V_t) (mph).
2. Select the horizontal line in the Table corresponding to the railway design speed,
3. Move to the right to the column under the T_{SSD} required for the crossing.

Repeat these steps for each road approach.

Note: If the road design speed or the railway design speed varies on either side of the grade crossing, you must do stand-alone calculations for each quadrant.

Table 4 – Minimum Sightlines along the Rail Line (D_{ssd}) (as illustrated in Figure 2)

Railway Design Speed V_t (mph) **WARNING**: Railway design speed in **mph**!	Stopping Sight Distance Time T_{SSD} (seconds) — Minimum Sightlines along Rail Line (D_{SSD}) (m)											If T_{ssd} > 20 sec., add for each additional second (m)
	≤ 10	11	12	13	14	15	16	17	18	19	20	
STOP	30	30	30	30	30	30	30	30	30	30	30	+0
1-10	45	50	55	60	65	70	72	76	80	85	90	+5
11-20	90	100	110	120	125	135	145	155	165	170	180	+10
21-30	135	150	165	175	190	205	215	230	245	255	270	+15
31-40	180	200	220	235	250	270	285	305	325	340	360	+20
41-50	225	250	270	290	315	335	360	380	405	425	450	+25
51-60	270	300	325	350	380	405	430	460	485	510	540	+30
61-70	315	350	380	415	445	470	505	535	565	595	630	+35
71-80	360	395	435	465	505	540	580	610	650	680	720	+40
81-90	405	445	490	535	570	605	650	685	730	765	810	+45
91-100	450	500	540	580	630	670	715	760	805	850	895	+50

You may use the formula below as an alternative to Table 4:

Formula: $D_{SSD} = 0.278 \times V_t \times T_{SSD}$ (m)
**** Convert mph –> km/h: mph x 1.6 ****

Where :

V_t = railway design speed (km/h)

T_{SSD} = [(SSD + cd + L) / (0.278 x V)] Stopping Sight Distance Time (from Step 1) (s)

Road approach 1 D_{SSD} = __________ (m)
(applicable to both sides of road approach if V_t similar)

Road approach 2 D_{SSD} = __________ (m)
(applicable to both sides of road approach if V_t similar)

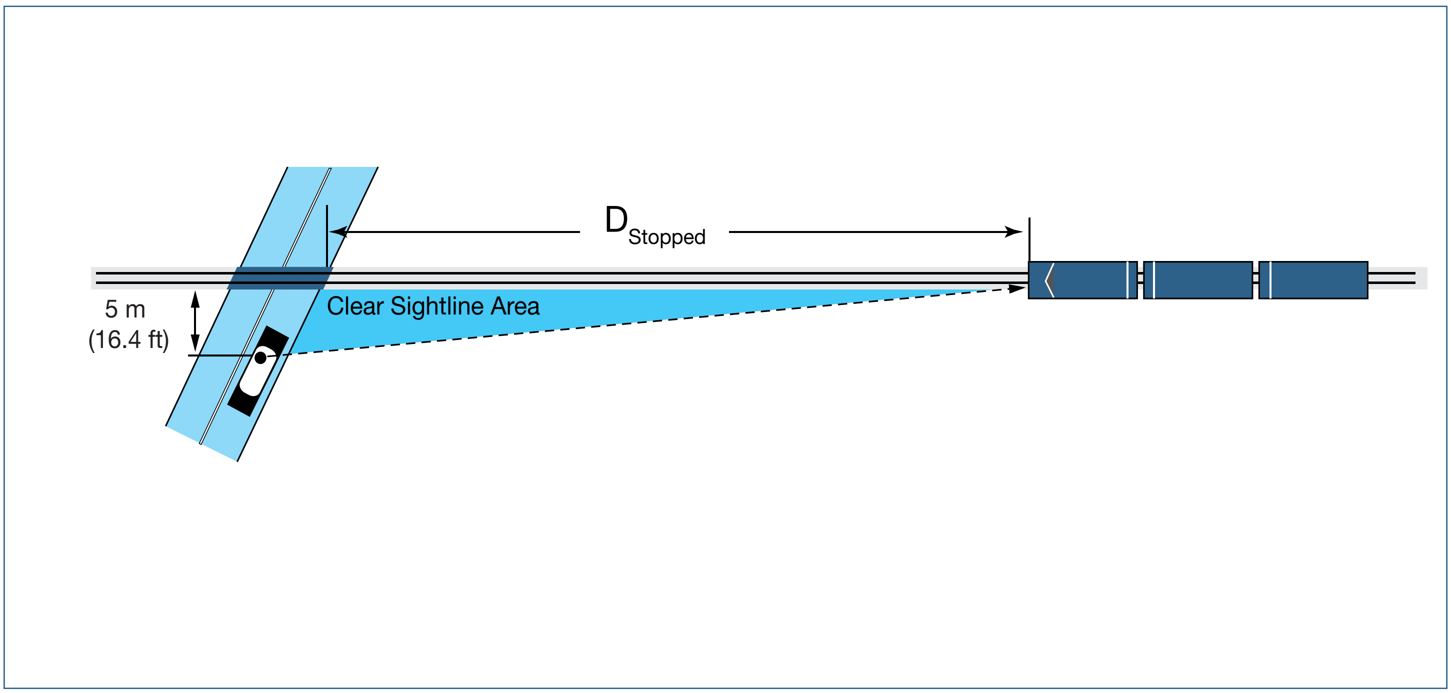
2.2.2 Determining Sightlines from the Stopped Position

$D_{stopped}$ is the minimum distance along the line of a crossing that a user needs to see approaching railway equipment, from the stopped position, and safely cross over the grade crossing.

To establish $D_{stopped}$, you must:

1. Determine the distance to travel during acceleration over the grade crossing.
2. Use the acceleration curves below to establish the acceleration time of the design vehicle.
3. Use the acceleration time to establish the time required for the design vehicle, or the pedestrian/cyclist/assistive device, to safely clear the crossing ($T_{stopped}$).
4. Use the greater of the two values to determine the $D_{stopped}$ measurement needed for sightlines from a stopped position.

Figure 3 – Minimum Sightlines for Drivers stopped at a Grade Crossing



Determining minimum sightlines from the stopped position is a six step process. The values determined in Steps 1 to 6 below define the minimum clear sightline area required for the stopped position, as indicated in Figure 3 above. This value may be different for each road approach. Although Figure 3 illustrates only one quadrant, in the field, you must verify the clear sightline area for all four quadrants (i.e. to the right and left sides of each road approach).

Step 1

Calculate distance to travel during acceleration (s) using the formula below:

Formula: s = cd + L, where:

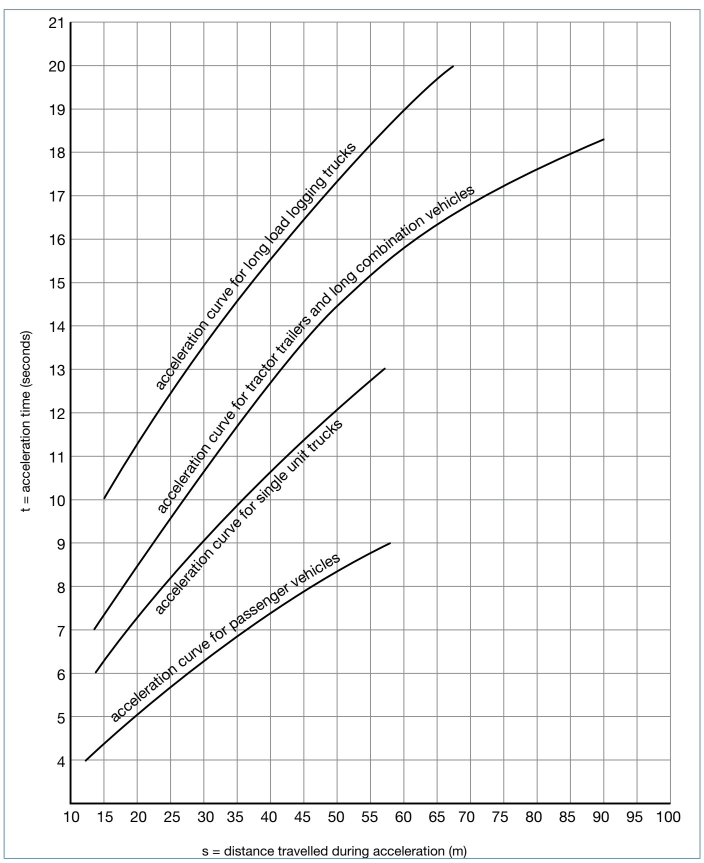
- cd = grade crossing clearance distance (m) (see Figure 1)
- L = length of grade crossing design vehicle (m) (see Table 1)

s = ____________ (m)

Step 2

Determine the acceleration time (t) from Graph 1 below:

Graph 1 – Acceleration Curves



Source: *Geometric Design Guide for Canadian Roads,* TAC; September 1999.

Note: For Design Vehicles not represented in this Graph, you may perform tests or estimate the acceleration time.

t = ____________ (s)

Step 3

Calculate the Design Vehicle Departure Time (T_d) for each road approach direction using the formula below:

Formula: $T_d = 2 + (t \times G)$ *, where:

- G = ratio of acceleration times on grades based on Table 5, below. Road grade in Table 5 is the average road gradient over the Design Vehicle length when at the stopped position; this value can be different for each road approach to the grade crossing.
- t = acceleration time from Step 2 (s)

Table 5 – Ratios of Acceleration Times on Grades

Grade Crossing Design Vehicle	Road Grade (%)				
	-4	-2	0	+2	+4
Passenger Car	0.7	0.9	1.0	1.1	1.3
Single Unit Truck & Buses	0.8	0.9	1.0	1.1	1.3
Tractor-Semitrailer	0.8	0.9	1.0	1.2	1.7

Source: *Geometric Design Guide for Canadian Roads,* Transportation Association of Canada; September 1999.

Note: For Design Vehicles not represented in this Table, you may perform tests or estimate the ratio of acceleration times on grades.

* You may consider adding more time to the calculated time, in accordance with the Acceleration Curves of Graph 1, to account for reduced acceleration caused by the crossing surface, taking into account the number of tracks, surface roughness, super-elevation of the tracks, any unevenness created by the crossing angle, any restrictions on shifting gears while crossing tracks.

Road approach 1 T_D = __________ (s)
Road approach 2 T_D = __________ (s)

Step 4

Calculate Departure Time for Pedestrians, Cyclists and Persons using assistive Devices (T_p), using the formula below:

Formula: $T_p = cd/V_p$, where:

- cd = grade crossing clearance distance (m)
- V_p = The average travel speed, in metres per second (m/s), for pedestrians, cyclists and persons using assistive devices (to a maximum value of 1.22 m/s)

T_p =_____ (s)

Step 5

Determine the departure time ($T_{stopped}$) for each road approach using the formula below:

Formula: $T_{stopped}$ = the greater of the departure times (T_d or T_p)

Road approach 1 $T_{stopped}$ =________ (s)
Road approach 2 $T_{stopped}$ =________ (s)

Step 6

Calculate $D_{stopped}$ for each road approach using Table 6 OR the formula indicated below Table 6, using T_d and T_p for both options.

Note: You must:

1. Calculate the departure time for the design vehicle or the pedestrian/cyclist (T_d or T_p) (from Step 5) required for the crossing and to determine the railway design speed (V_t) (mph).
2. Select the horizontal line in Table 6 corresponding to the railway design speed,
3. Move to the right to the column under the $T_{stopped}$ (greater of T_d or T_p).

Repeat this process for each road approach.

Note: If the road design speed or the railway design speed varies on either side of the grade crossing, you must do stand-alone calculations for each quadrant.

Table 6 – Minimum Sightlines along the Rail Line ($D_{stopped}$) (as illustrated in Figure 3)

Railway Design Speed V_t (mph) **WARNING**: Railway design speed in mph!	$T_{stopped}$ = Departure Time (greater of T_d or T_p) (seconds)											If greater of T_d or T_p > 20 sec., add for each additional second (m)
	≤ 10	11	12	13	14	15	16	17	18	19	20	
	Minimum Sightlines along Rail Line ($D_{stopped}$) (m)											
STOP	30	30	30	30	30	30	30	30	30	30	30	+0
1-10	45	50	55	60	65	70	72	76	80	85	90	+5
11-20	90	100	110	120	125	135	145	155	165	170	180	+10
21-30	135	150	165	175	190	205	215	230	245	255	270	+15
31-40	180	200	220	235	250	270	285	305	325	340	360	+20
41-50	225	250	270	290	315	335	360	380	405	425	450	+25
51-60	270	300	325	350	380	405	430	460	485	510	540	+30
61-70	315	350	380	415	445	470	505	535	565	595	630	+35
71-80	360	395	435	465	505	540	580	610	650	680	720	+40
81-90	405	445	490	535	570	605	650	685	730	765	810	+45
91-100	450	500	540	580	630	670	715	760	805	850	895	+50

As an alternative to Table 6, the corresponding formula may be used:

Formula: $D_{stopped} = 0.278\, V_t \times T_{stopped}$
**** Convert mph –> km/h : mph x 1.6 ****

Where:

- V_t = railway design speed (km/h)
- $T_{stopped}$ = departure times as calculated in Step 5 (s)

Road approach 1 $D_{stopped}$ = __________ (m)
(applicable to both sides of road approach if V_t similar)

Road approach 2 $D_{stopped}$ = __________ (m)
(applicable to both sides of road approach if V_t similar)

Congratulations! You are done!

2.3 Learn More

If you have questions or want to learn more about sightlines at grade crossings, please contact us by email or phone.

Email: *railsafety@tc.gc.ca*

Phone: 613-998-2985