IDAHO
TRANSPORTATION DEPARTMENT

GUIDELINES FOR INSTALLATION, INSPECTION AND MAINTENANCE OF COMMONLY USED SAFETY BARRIER SYSTEMS IN IDAHO

MAY 2019

HIGHWAY SAFETY BARRIER POCKET GUIDE

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The Federal Highway Administration (FHWA), under the FAST Act Grant, sponsored this guide.

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Contents

Disclaimer

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The purpose of this pocket guide is to present basic guidelines for guardrail installers, inspectors, and maintenance personnel. This pocket guide presents information contained in the AASHTO *Roadside Design Guide*, 4th Edition, the ITD *Roadway Design Manual*, and the ITD Standard Drawings. Barrier installations are to be built and maintained to current ITD standard drawings and manufacturers' recommendations.

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
BLON	Beginning Length of Need
CIP	Critical Impact Point
FARS	Fatal Analysis Reporting System
FAST ACT	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
HTC	High Tension Cable
LON	Length of Need
MUTCD	Manual on Uniform Traffic Control Devices
MASH	Manual for Assessing Safety Hardware
MGS	Midwest Guardrail System
NCHRP	National Cooperative Highway Research Program
RDG	Roadside Design Guide
ROR	Run-off-Road
ROW	Right-of-Way
SHSP	Strategic Highway Safety Plan
SPWB	Strong Post W-Beam
TL	Test Level
VMT	Vehicle Miles Traveled
WZ	Work Zone

Frequently Asked Questions

When reviewing proposed and existing barrier installations in the field, the project team should consider the following questions:

1. Is the obstacle being shielded significantly more severe than the barrier itself; and secondly, what is the likelihood of the obstacle being struck? (page 5, **Roadside Obstacle**)

2. Are there any vertical rigid objects within the guardrail system's design **deflection**? (page 14, **Deflection**)

3. For existing installations, does the existing guardrail **height** meet criteria? (page 16, **Slope in Front of Barrier — Height**)

4. Is the **slope in front** of the barrier appropriate? (page 16, **Slope in Front of Barrier**)

5. If a high-speed facility, are there **curbs** in combination with guardrail? (page 17, **Guardrail in Combination with Curbs**)

6. Is there adequate soil support behind the guardrail shielding a non-recoverable fill slope or has the design been appropriately modified? (page 19, **Soil Backing**)

7. Is the guardrail installation long enough to shield the obstacle? (page 20, **Length of Need**)

8. Should the guardrail be extended upstream to shield other warranting obstacle(s)? (page 22, **LON Field Check**)

9. Is an appropriate terminal being used? (page 24, **Terminals**)

10. Is the **grading** around the terminal (approach, adjacent, and runout distance) appropriate? (page 36, **Terminal Grading Details**)

11. Does the guardrail end within 200 ft of the start of another guardrail run that could be connected? (page 23, **Gaps**)

This document, used in conjunction with field reviews and appropriate ITD manuals, practices, policies and procedures, and Standard Drawings, provides the information needed to answer these questions and help personnel install and maintain appropriately performing barriers.

Introduction

Barrier systems are designed and installed for one primary reason — to reduce the severity of a crash by preventing a motorist from reaching a more severe hazard.

The first priority would be to remove the hazard (or redesign it so it is no longer a hazard). When the hazard cannot be acceptably mitigated, then a decision is made as to whether installing a barrier is the most appropriate treatment for the situation. The following itemizes this approach:

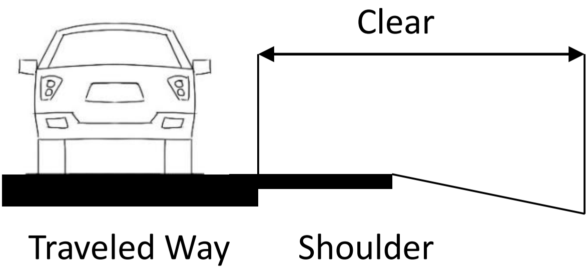
Order of Preference

1. Remove the obstacle.
2. Redesign the obstacle so it can be safely traversed.
3. Relocate obstacle to a point where it is less likely to be struck.
4. Use an appropriate breakaway design to reduce impact severity breakaway design.
5. Shield the obstacle with a longitudinal traffic barrier designed for redirection or use a crash cushion.
6. Delineate the obstacle if the previous alternatives are not appropriate.

(AASHTO *Roadside Design Guide*, 4th Edition, Pg. 1-4)

Clear Zone

The clear zone is defined as the unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles. The clear zone includes shoulders, bike lanes, and auxiliary lanes, except those auxiliary lanes that function like through lanes.



There is a distinction between available clear zone and design clear zone. *Available clear zone* is that area **existing** for recovery. *Design clear zone* is a selected value used for design to provide recovery area for the majority of errant drivers.

The available clear zone should not be compromised.

The **Principle** is that the amount of clear zone should be as wide as is practical.

(AASHTO *Roadside Design Guide*, 4th Edition, 2011, 3.1 The Clear-Zone Concept)

The designer selects a project clear zone value from table 3-1 of the AASHTO *Roadside Design Guide (ITD guidance)*. Selection is based on the highway design speed, cross-section features, slope condition, and traffic volumes. The designer may adjust (increase) the width on the outside of horizontal curves.

Design Speed (mph)	Design ADT	Foreslopes			Backslopes		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
≤40	UNDER 750[c]	7-10	7-10	b	7-10	7-10	7-10
	750-1500	10-12	12-14	b	10-12	10-12	10-12
	1500-6000	12-14	14-16	b	12-14	12-14	12-14
	OVER 6000	14-16	16-18	b	14-16	14-16	14-16
45-50	UNDER 750[c]	10-12	12-14	b	8-10	8-10	10-12
	750-1500	14-16	16-20	b	10-12	12-14	14-16
	1500-6000	16-18	20-26	b	12-14	14-16	16-18
	OVER 6000	20-22	24-28	b	14-16	18-20	20-22
55	UNDER 750[c]	12-14	14-18	b	8-10	10-12	10-12
	750-1500	16-18	20-24	b	10-12	14-16	16-18
	1500-6000	20-22	24-30	b	14-16	16-18	20-22
	OVER 6000	22-24	26-32[a]	b	16-18	20-22	22-24
60	UNDER 750[c]	16-18	20-24	b	10-12	12-14	14-16
	750-1500	20-24	26-32[a]	b	12-14	16-18	20-22
	1500-6000	26-30	32-40[a]	b	14-18	18-22	24-26
	OVER 6000	30-32[a]	36-44[a]	b	20-22	24-26	26-28
65-70[d]	UNDER 750[c]	18-20	20-26	b	10-12	14-16	14-16
	750-1500	24-26	28-36[a]	b	12-16	18-20	20-22
	1500-6000	28-32[a]	34-42[a]	b	16-20	22-24	26-28
	OVER 6000	30-34[a]	38-46[a]	b	22-24	26-30	28-30

See AASHTO Roadside Design Guide, 4th Edition 2011, Chapter 3, Table 3-1, Pg 3-3.

NOTES:

a) When a site-specific investigation indicates a high probability of continuing crashes, or when such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear zones shown this table. Clear zones may be limited to 30 ft. for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

b) Because recovery is less likely on unshielded, traversable 1V:3H fill slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the recovery area at the toe of the slope should consider right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through travelled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of the slope. While the application may be limited by several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in the AASHTO Roadside Design Guide, AASHTO 2011, Figure 3-2. A 10-ft recovery area at the toe of the slope should be provided for all traversable, non-recoverable fill slopes.

c) For roadways with low volumes, it may not be practical to apply even the minimum values found in the Table. Refer to Chapter 12 for additional considerations for low-volume roadways and Chapter 10 for additional guidance for urban applications in the AASHTO, Roadside Design Guide, 2011 for more information.

d) When design speeds are greater than the values provided, the designer may provide clear-zone distances greater than those shown in Table.

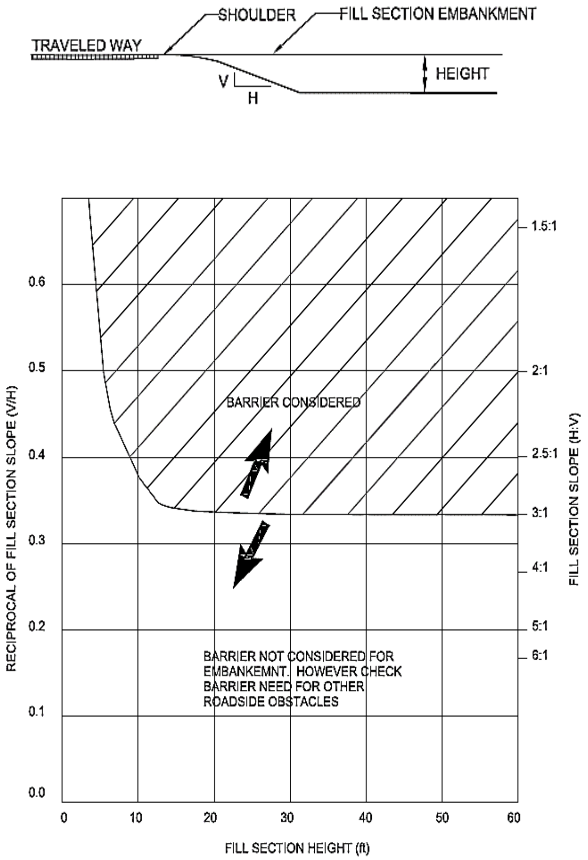
Roadside Obstacles

In general, barrier warrants are based on the relative severity between impacting the barrier and impacting the obstacle. The AASHTO *Roadside Design Guide* lists typical hazards along the roadway:

Obstacle	Guidelines
Bridge piers, abutments, and railing ends	Shielding generally needed.
Boulders	Judgment decision based on nature of fixed object and likelihood of impact.
Culverts, pipes, headwalls	Judgment decision based on size, shape and location of obstacle.
Foreslopes and backslopes (smooth)	Shielding not generally required.
Foreslopes and backslopes (rough)	Judgment decision based on likelihood of impact.
Ditches (parallel)	Refer to Figures 3-6 and 3-7 in *Roadside Design Guide*.
Ditches (transverse)	Shielding generally required if likelihood of head-on impact is high.
Embankment	Judgment decision based on fill height and slope (see figure 5-1 in *Roadside Design Guide*).
Retaining Walls	Judgment decision based on relative smoothness of wall and anticipated maximum angle of impact.
Sign/luminaire supports	Shielding generally required for nonbreakaway supports.
Traffic signal supports	Isolated traffic signals within clear zone on high-speed rural facilities may need shielding.
Trees	Judgment decision based on site-specific circumstances.
Utility poles	Shielding may be needed on a case-by-case basis.
Permanent bodies of water	Judgment decision based on location and depth of water and likelihood of encroachment.

Roadside Slopes (Embankments)

The severity of the roadside embankment depends upon the steepness and height of the fill slope. The figure below shows AASHTO guidance:



The designer may perform a cost-benefit analysis to help assess the necessity of a barrier for all hazards.

Barriers

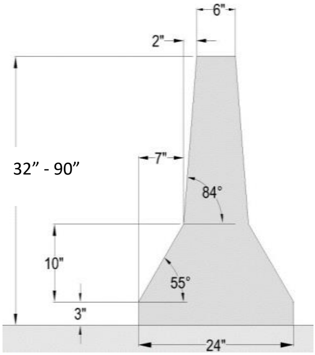
A roadside barrier is a longitudinal barrier used to shield motorists from natural or man-made obstacles located along either side of a traveled way. Barriers are usually categorized as rigid, semi-rigid, or flexible, depending on their deflection characteristics when struck under (NCHRP 350) MASH TL-3: pickup truck at 62 mph and 25 degrees impact angle.

For more information, see FHWA Resource Charts at http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/

Rigid Systems

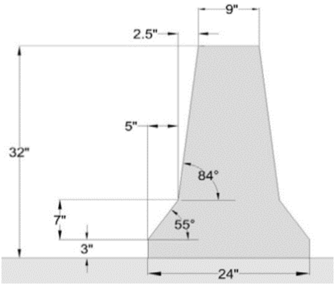
Rigid Barrier Systems have little (between 0 to 1 ft.) deflection under the TL-3 conditions described above. The rigid barrier system should be anchored by some acceptable means. The most prevalent rigid barrier in use during the 1970s and 1980s was the New Jersey Safety Shape.

The flatter lower slope is intended to redirect vehicles impacting at shallow angles with little vehicle damage but that can cause instability to vehicles impacting at high speeds and angles.



(AASHTO *Roadside Design Guide*, 4th Edition, 2011, Chapter 5. Roadside Barriers)

In an effort to improve the performance, testing was conducted that led to the development of the F-Shape. Similar in shape to the New Jersey barrier, the lower height of the breakpoint allowed increased stability and less lift with both the small car and the pickup.



ITD predominantly uses free-standing pre-cast concrete safety shape; however, the new standard is the F-Shape. Consideration must be given to the fact that free-standing concrete sections are NOT rigid barriers — they can deflect over 5 ft.

If the barrier is 42 in. high or more, AND structurally anchored, it is then considered TL-5 capable of containing an 80,000 lb. tractor-trailer design impact.

The Zone of Intrusion is related to a large vehicle leaning over the barrier after impact and possibly striking a vertical obstacle. Bridge engineers have a particular concern for bridge piers and have recommended that any barrier within 10 ft. of the pier be 54 in. tall. The *Roadside Design Guide* suggests the taller barrier begin 10 ft. in advance of the obstacle preceded by a 10:1 slope to the normal barrier height.

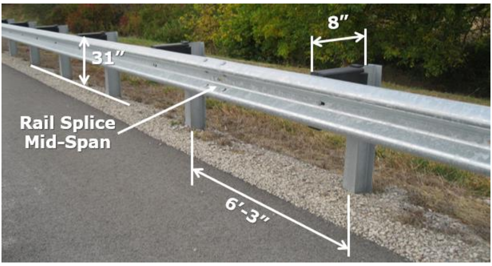
Semi-Rigid System

Semi-rigid barrier systems have deflections of a few feet (between 2 – 5 ft.) under the TL-3 pickup impact conditions. Terminate these systems with an anchor on both ends (crashworthy on approach ends) to maintain the tension in the rail. The ITD current standard for new construction is commonly known as the Midwest Guardrail System (MGS). However, crews will need to maintain the many miles of the previous ± 27¾ in. Guardrail (*Old*) System that sometimes remains in place on 3R projects, and possibly maintenance.

The major differences between the ± 27¾ in. *old* Guardrail System and the MGS are the shifting of the W-beam rail splices from the posts to mid-span between posts and raising the rail height to 31 in. These two changes provided a stronger system and better performance with higher center-of-gravity/bumper-height pickup vehicles. The MGS guardrail system uses the same rail element as the 27¾ in. Guardrail System (with slotted rail-to-post holes punched every 3 ft., 1½ in.) and the same posts.

Midwest Guardrail System (MGS)

Test Level: MASH TL-3



Rail Splice between posts

Height: 31 in.

Post: W6 x 9 or W6 x 8.5 ft. x 6 ft. Steel or 6 in. x 8 in. x 6 ft. wood posts.

Post Spacing: 6 ft., 3 in.

Blocks: 6 in. x 8 in. timber or plastic block.

± 27¾ in. Guardrail (*Old*) System

Test Level: NCHRP 350(MASH TL-3 steel post only)

Rail Splice on Posts

Height: ± 27¾ in.

Post: W6 x 9 or W6 x 8.5 x 6 ft. steel or wood 6 in. x 8 in. x 6 ft.

Post Spacing: 6 ft., 3 in.

Blocks: 6 in. x 8 in. timber or plastic block.

Rail Lapping (± 27¾ in. and MGS). Guardrail is lapped in the direction of travel of the adjacent traffic. Although the chance of snagging on the end of a rail panel during impact is unlikely, reverse lapping is problematic for some maintenance activities (e.g., plowing snow). Rail lapping is also an important indicator of the quality of the installers' workmanship.

Flexible Systems

Low-Tension Cable (LTC) Barrier is a generic design used by some States for many years. Although LTC Barrier is an effective barrier, it generally requires prompt repair after most impacts to restore the effectiveness of the system.

It is a 3-cable configuration attached with hook bolts and a weak-post spacing of 4 ft. to 16 ft.

A newer variation of the cable barrier is the High-Tension Cable (HTC) Barrier. As the name implies, these barriers are installed with the cables placed under significant tension (>5000 lbs., depending on manufacturer and temperature); they are typically used in the median, though roadside applications are appropriate. A major advantage of these HTC systems is that the cables remain near the proper height after most normal impacts (with damage limited to a few posts) so that the barrier is still effective. The HTC systems do undergo rather large deflections (around 8 ft.) when compared to rigid and semi-rigid barriers, which agencies must consider. Post spacing and type and cable heights and attachment vary with the manufacturer.

Idaho currently allows the following systems, which should be installed in accordance with the manufacturer's recommendations and meet the ITD general requirements, but only after proper training for both the installer and inspector.

CASS system by Trinity
http://www.highwayguardrail.com/products/cb.html

Post: System dependent — can be driven or socketed.
Cable: Some cables are placed in a wave-shaped slot at the center of the post and separated by plastic spacers. Some may be retained with a hook bolt on the outside. Install according the manufacture's manual.

Gibraltar

http://gibraltarus.com/en/highway-cable-barrier

Post: C-channel post can be driven or socketed.

Cable: Cables are attached using a single hair pin and are placed on alternate sides of adjacent posts.

Brifen Wire Rope Safety Fence (WRSF) 3 and 4 wire by Brifen USA

http://www.brifenusa.com/

Post: Z-shaped post can be driven or socketed

Cable: Top cable is placed in a center slot at top of the post and cables 2 and 3 and/or 4 are weaved around posts and supported by post pegs.

Barrier Design Principles

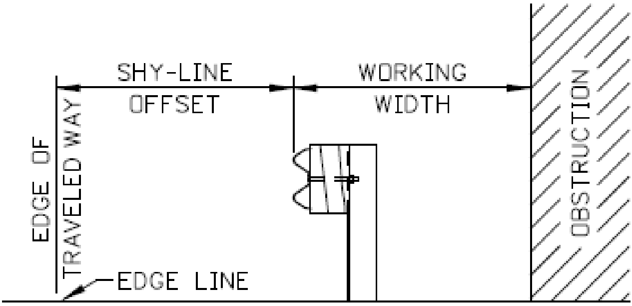
There are five principles of barrier design that should be addressed to ensure a barrier installation performs as designed. Some of these principles differ between the MGS and ± 27¾ in. guardrail system; these differences are noted in the following guidance.

Note that the 27¾ in. guardrail system was tested to NCHRP 350 criteria (and successfully to MASH as a steel-post system only); the MGS was tested to MASH with steel and wood posts.

Deflection

The needed deflection distance is based on the results of 62 mph impacts into the guardrail at a 25 degree impact angle by a pickup truck. The typical deflection distance used in the past was 3 ft from the back of the post for ± 27¾ in. strong post W-beam.

Deflection for the ITD MGS system is addressed by the working width from the front face of the barrier to a rigid object, shown on Standard 612-1, sheet 1.



PLACEMENT DETAIL

SEE NOTE NOS. 4 THROUGH 7

Values for this distance are also given on sheet 1 and depend of the stiffness of the system (the post spacing).

DEFLECTION TABLE		
APPLICATION	**POST SPACING**	**WORKING WIDTH**
NORMAL SPACING	**6'-3"**	**54"**
½ SPACING	**3'-1½"**	**46"**
¼ SPACING	**1'-6¾"**	**38"**
STEEP SLOPE	**6'-3"**	**56"**
HINGE POINT	**6'-3"**	**78"**
LONG SPAN	**≤ 25'**	**96"**

Stiffening should be added gradually so as not to create a hard point — see sheet 3 of Standard 612-1.

The deflection distance for HTC systems is significantly larger, around 8 ft with 10 ft post spacing; closer post spacing may reduce the deflection somewhat. See manufacturer instructions.

Slope in front of Barrier

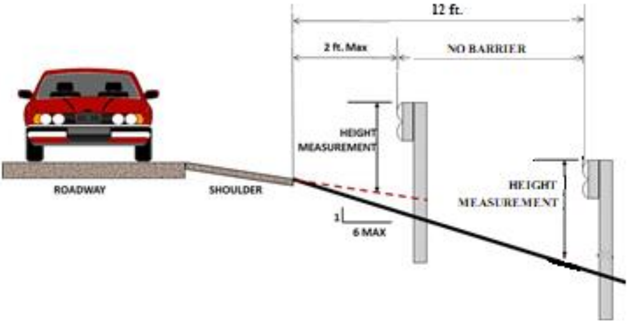
Barrier, regardless of type, performs best when the impacting vehicle is stable when contact is first made. A vehicle running off the road at high speed and crossing a hinge (slope break) point may become airborne and strike the barrier too high, resulting in override.

High-tension cable barrier can be placed on a 6:1 slope, but its location on the slope is critical when near a swale. Avoid the area from 1 ft to 8 ft from the ditch line. The cable has also been tested on 4:1 slopes with restricted locations (typically within 4 ft of the hinge point as well as out of the swale). It is important to follow manufacturer's guidelines.

Avoid placing rigid barriers where the slope leading to the barrier face exceeds 10:1.

The MGS system can be placed anywhere on a slope (relative to the slope only) as long as the slope in front of the barrier is flat (10:1 or flatter); measure the height from the ground directly beneath the face of the rail. Construction tolerance should be ± 1 in. from the nominal height.

The 27 in. guardrail system can also be placed anywhere on a 10:1 slope. In addition, the 27 in. system has been placed on slopes as steep as 6:1, with restrictions: with slopes steeper than 10:1 but no steeper than 6:1, the face of the barrier could have been either up to 2 ft from hinge point or at least 12 ft down the slope from the hinge point; THIS IS NO LONGER APPROPRIATE. In locations where 27 in. system was placed up to 2 ft off the edge of pavement, the height was measured in accordance with figure below. AGAIN, THIS IS NO LONGER APPROPRIATE

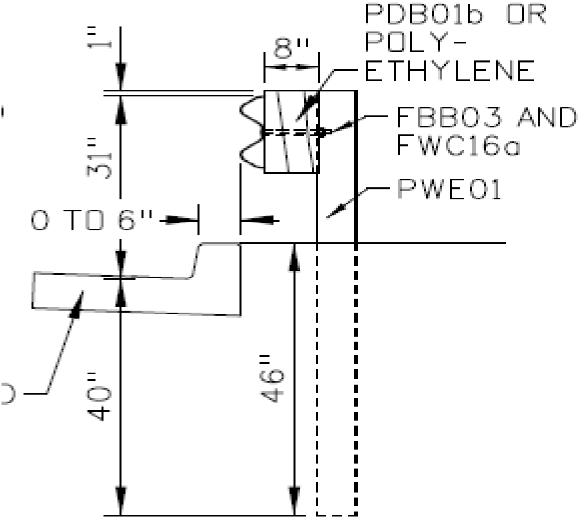


***27 in. Guardrail System* — Location and Height Measurement on a 6:1 Slope**

Guardrail in Combination with Curb

The use of curb in combination with guardrail on high-speed facilities is generally not desirable.

ITD Standard 612-1 allows for 6 in. curb with the face of curb no more than 6 in. in front of the face of the guardrail as shown in the detail below (for both post types).



CURB
APPLICATION

For low speed, MASH TL-2 **(<45 MPH**) applications, the MGS guardrail system has been successfully tested to MASH with the guardrail located 6 ft behind the face of a 6 in. high vertical concrete curb, which had been determined to be the worst location.

Soil Backing

If guardrail is shielding a steep (2:1) embankment, then there should be sufficient soil support behind the post to provide for the post's strength. The *normal application* for guardrail typical sections, Standard 612-1 shows 2 ft of grading at 10:1 max slope behind the post.

For the MGS, when the 2 ft backing cannot be reasonably provided, Standard 612-1 shows placement of a 6 ft post (with blockout) centered on the hinge point — either post type, but only when shown on the plans per note 3 on sheet 5. The Standard also shows an 8 ft long steel post placed 18 in. max (to back of post) down a 2:1 slope from the hinge point. A last option allows a 6 ft, steel only, post at either normal application or at the hinge point without a blockout — but only with explicit approval.

The 27 in. guardrail system was allowed with a 7 ft post placed at the slope break point of a 2:1 slope at half post spacing for high-speed conditions.

Flare Rate

If a barrier is placed on a flare, then it moves the barrier and terminal farther away from the edge of traffic and reduces the amount of barrier needed. If the barrier is flared, two features must be considered: the slope in front of the barrier must be 10:1 or flatter; and the flare rate must satisfy the allowable values given in the AASHTO RDG, as the tables below show.

(Previously, ITD allowed 5:1 flare outside shy distance.)

Design Speed (mph)	Flare Rate for Barrier Inside the Shy Line	Flare Rate for Barrier at or Beyond Shy Line	
		Rigid Barrier	Semi-Rigid Barrier
70	30:1	20:1	15:1
60	26:1	18:1	14:1
55	24:1	16:1	12:1
50	21:1	14:1	11:1
45	18:1	12:1	10:1
40	16:1	10:1	8:1
30	13:1	8:1	7:1

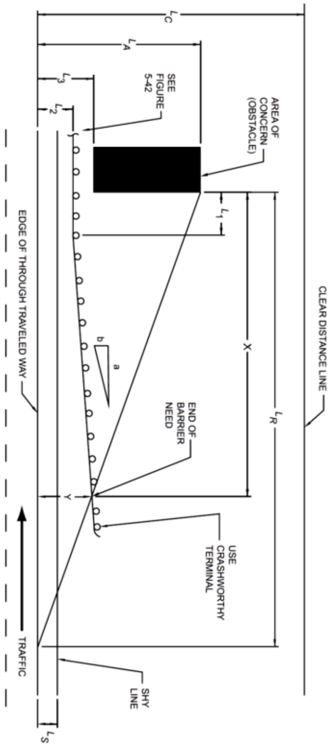
SHY LINE OFFSET TABLE	
DESIGN SPEED (MPH)	SHY-LINE OFFSET (FT)
80	12
70	9
60	8
55	7
50	6.5
45	6
40	5
30	4

Length of Need (LON)

Length of Need (X) is defined as the length of fully effective barrier needed in advance of the hazard to prevent an approaching vehicle from reaching the shielded hazard. The designer determines this length by selecting the appropriate variables, as shown in the figure and calculating *X* by using one of the following equations:

$$X = \frac{L_A - L_2}{(L_A / L_R)}$$

$$X = \frac{L_A + (b/a)(L_1) - L_2}{b/a + (L_A / L_R)}$$

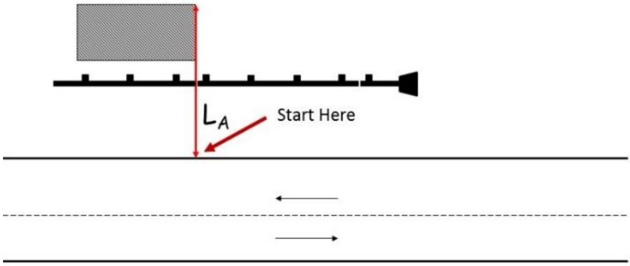


Determination of Adjacent LON

LON Field Check

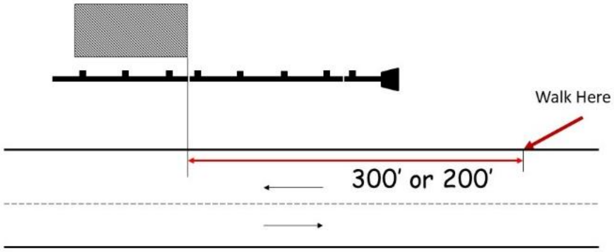
The following provides a guide for how to perform a quick check in the field to verify that the approximate LON exists:

Stand on the edgeline directly opposite the upstream end of the hazard.



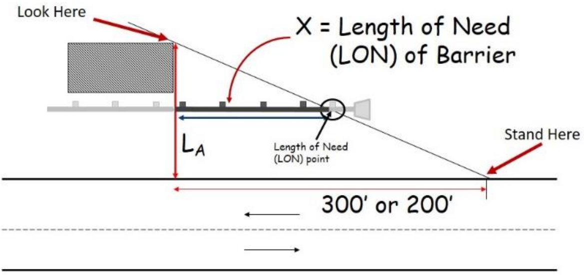
Stand at Upstream End of Obstacle

Pace off upstream along the edgeline 300 ft (for high speed, 200 ft for lower speed).



Pace off Upstream

From that point, turn and look at the back of the hazard — limited to 30 ft.



Line of Sight to Back of Obstacle

If the proposed (or actual) guardrail installation crosses (or is close ± 30 ft) that line of sight, then the hazard is approximately covered.

LON may need to be checked for the opposing direction of traffic as well; this time the pacing would be from the downstream end of the hazard and would be along the centerline.

Pay special attention and appropriately address all hazards in the immediate vicinity that would warrant shielding by themselves. There may be other warranting hazards near an obvious obstacle (i.e., the bridge pier), such as a steep transverse embankment within the clear zone that should be considered in determining adequate length of barrier.

Gaps

Avoid short gaps between runs of barrier. National guidance suggests connecting gaps less than 200 ft between barrier termini into a single run. Exceptions may be necessary for access or other project considerations.

Terminals and Crash Cushions

Terminals

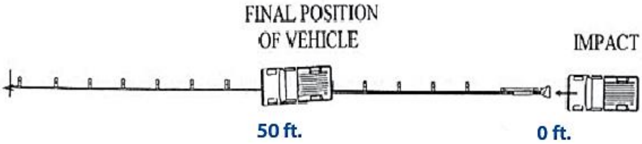
Crashworthy terminals serve two functions: develop anchorage for guardrail for downstream impacts and are crashworthy when struck on the end.

Terminal Types. ITD uses three types of terminals: Buried-in-Backslope (BIB), flared, or tangent.

All newly installed tangent terminals will meet MASH 2016 criteria. Flared terminals must meet NCHRP 350, and currently scheduled for MASH by 12/31/19. The BIB Standard 612-6 meets MASH.

Buried-in-Backslope (BIB) is the preferred treatment when a cut slope is present (or close by). When properly designed and installed, it adequately shields the hazard(s) and cannot be impacted end-on. There are two configurations for the BIB, based on slope in front of the rail. Use a double stack rail where the slope is steeper than 10:1 but no steeper than 4:1. A single rail BIB may be used if the slope in front is 10:1 or flatter all the way to the toe of the backslope – contact HQ design. The backslope is typically 2:1 (or steeper), but the BIB can be used with 3:1 backslopes. Once passing over the toe of the backslope, the rail is buried 1 ft underground at the end post to develop anchorage. The point where the rail passes over the toe of the backslope is the BLON of the BIB and must be far enough in advance of the hazard such that if a vehicle climbed over the buried end, it would not reach the hazard — immediately if an essentially vertical slope (rock), 75 ft minimum if a 2:1 slope, and determined by the formula (field check) if flatter than 2:1.

All of the ITD-approved **tangent** terminals function as **energy-absorbing terminals**. Crash testing has shown that an energy-absorbing terminal can stop an impacting pickup truck, travelling at 62 mph, in about 50 ft when struck head-on (as shown in figure). Recognize, however, that a vehicle at a higher angle impact on the end will pass through the terminal and travel a considerable distance behind.



Energy-absorbing Terminals

MASH Sequential Kinking Terminal (MSKT)

For current details of this system, see Manufacturer's Installation/Assembly Manual at:

http://www.roadsystems.com/mash-mskt/

Test Level: MASH 16: TL-3

Distinguishing Characteristics:

- Square impact head.
- Enclosed feeder chute (SKT engraved).
- Post 1 Tube top section, W6 x 15 bottom section.
- Post 2 steel-hinged post.
- Posts 3 – 8 standard 6 ft long posts.
- Other features same as the previously approved SKT 350. See below.

How it works: This is an energy-absorbing system. The energy of a vehicle in a head-on impact is absorbed by the impact head being forced down the rail elements deforming them in short kinks. This is a compression-based system. For higher angle hits on the nose, the vehicle breaks away the end and passes through and behind the guardrail. For side impacts beyond the BLON point (post 3), the vehicle should be redirected in front of the rail.

SoftStop

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:

http://www.highwayguardrail.com/products/SoftStop.html

Test Level: MASH 16: TL-3

Distinguishing Characteristics:

- Narrow, rectangular impact head and chute.
- Anchor post in front of the impact head (post #0).
- Post 1, 4 ft, 9½ in. SYTP (Steel Yielding Terminal Post).
- Post 2, 6 ft SYTP.
- Posts 3 – 8, standard 6 ft long posts.
- End rail element is split, passes through the impact chute, and is connected (with two bolts) to post 0 (the foundation post)

How it works: This is an energy-absorbing system. The energy of a vehicle in a head-on impact is absorbed as the impact head and chute is forced down the rail, vertically crushing the rail as it goes through the chute. **This is a tension-based system**; there is no cable release. For higher angle hits on the nose, the vehicle pushes over the guardrail and passes through and behind the guardrail. For side impacts beyond the BLON point (16½ ft from post 0), the vehicle should be redirected in front of the rail. (Adaption is needed to connect to the 27 in. system.)

MAX-Tension

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:

http://www.barriersystemsinc.com/guardrail-end-treatments

Test Level: MASH16: TL-3
Distinguishing Characteristics:

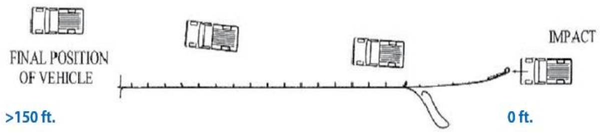
- Impact head contains friction plate.
- Anchor post in front of the post 1.
- Post 2 and beyond — standard steel line posts.
- SaberTooth cutting piece cuts downstream rail, absorbing energy.

How it works: This is an energy-absorbing system. The energy of a vehicle in a head-on impact is absorbed as the impact head moves the friction plate over the anchored cables, and the SaberTooth device cuts the downstream rail. This is primarily a tension-based system, as there is no cable release. For higher angle hits on the nose, the vehicle pushes over the guardrail and passes through and behind the guardrail. For side impacts beyond the BLON point (post 3), the vehicle should be redirected in front of the rail. (Adaption is needed to connect to the 27 in. system.)

NOTES:

- On two-lane highways with two-way traffic, crashworthy end treatments are typically used on both the approach and trailing ends of guardrail runs (possibly even if the trailing end is outside the clear zone of the opposing traffic).
- On four-lane divided highways, non-crashworthy end treatments (Guardrail Anchor – Standard 612-5) are typically used on the departure ends (if they are well outside the clear zone for opposing traffic).
- Oftentimes no rail is needed on the departure ends of bridges on divided roadways unless site-specific circumstances require additional barrier.

The ITD-approved **flared** terminals function as either **energy-absorbing or non-energy-absorbing terminals**. The contractor will choose which device to use, but the design chosen must consider all outcomes. The Energy-absorbing system performs similar to the tangent systems described above and is compression based; it is the FLEAT described below. The figure below shows non-energy-absorbing system performance: For ANY angle hit on the nose, the vehicle will pass through and behind the system; it is the SRT described below. Again, whether it is energy-absorbing or non-energy-absorbing, a vehicle at a higher angle impact on the end will pass through the terminal and travel a considerable distance behind it.



Non-energy-absorbing Terminal

MASH Flared Energy-Absorbing Terminal (MFLEAT)

For current details of this system, see Manufacturer's Installation/Assembly Manual at: http://www.roadsystems.com/mash-mfleat/

Test Level: MASH: TL-3

Distinguishing Characteristics:

- Square impact head.
- Enclosed feeder chute.
- 39 ft.-7 in. straight flared length.
- 3 ft. offset.
- Posts 1-3 are steel-hinged post.
- BLON at post 4.
- Other features similar to the previously approved FLEAT 350, see below.

How it works: This is an energy-absorbing terminal, which is also a flared terminal. The energy of a vehicle in a head-on impact is absorbed by the impact head being forced down the rails sequentially kinking them and extruding them on the traffic side of the guardrail.

Slotted Rail Terminal (SRT-31)

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:

http://www.highwayguardrail.com/products/et-srt350.html

Test Level: NCHRP 350: TL-3

Distinguishing Characteristics:

- No impact head.
- Rail connected to post 1.
- Strut between posts 1 and 2.
- Cable anchor bracket — solid attachment to rail.
- Longitudinal slots on two W-beam rail elements.
- Slot Guards on downstream end of slots.
- Posts 1 and 2 are proprietary steel-hinged posts; posts 3 – 7 are Steel Yielding Terminal Post (SYTP). See manufacture's installation manual.
- Post 1 offset - 4 ft. on a straight-line taper.

How it works: This is a non-energy-absorbing terminal. The slots in the slotted rail design allow the rails to collapse at engineered locations when struck end-on at most (including head-on) impact angles rather than penetrate a vehicle. For side impacts beyond the LON point (post 3), the vehicle should be redirected in front of the rail.

Flared Energy-absorbing Terminal (FLEAT)

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:

http://roadsystems.com/fleat.html

Test Level: NCHRP 350: TL-3

Distinguishing Characteristics:

- Rectangular impact head.
- Rail has 5 slots (½ in. x 4 in. long) on both the top and bottom corrugations of the W-beam section.
  (There may be three additional (½ in. x 4 in. long) slots in the valley of the rail – for use with the SKT).
- Steel and wood post options.
- End of W-beam rail offset 4 ft, 0 in. per Standard Drawing; successfully tested with as little as 2 ft –6 ft offset.

How it works: This compression-based energy-absorbing terminal is also a flared terminal. The energy of a vehicle in a head-on impact is absorbed by the impact head being forced down the rails kinking them in a tight curl extruding on the traffic side of the guardrail.

Existing Guardrail Terminal Systems

Sequential Kinking Terminal (SKT)

(Identification ONLY)

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:

http://roadsystems.com/skt.html

Test Level: NCHRP 350: TL-3

Distinguishing Characteristics:

- Square impact head.
- Steel and wood post options.
- Cable anchor bracket requires eight special shoulder bolts (heads on the back side) to connect to rail element.
- Has a feeder chute (channel section that surrounds the rail), which gets wider at the downstream end.
- Rail has 3 (½ in. x 4 in. long) slots in the valley of the rail (There may be five additional slots (½ in. x 4 in. long) on both the top and bottom corrugations of the W-beam section — this is for interchangeability with the FLEAT).

ET 2000
(Identification ONLY)

Extruder Terminal ET-Plus
(Identification ONLY)

For current details of these systems, see Manufacturer's Installation/Assembly Manual at website:

http://www.highwayguardrail.com/products/etplus.html

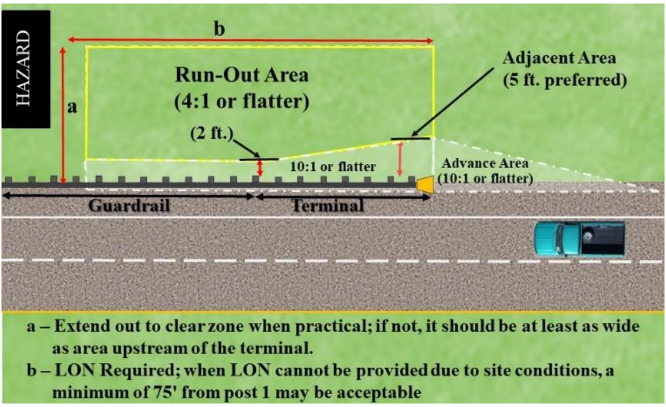
Test Level: NCHRP 350: TL-3

Distinguishing Characteristics:

- Square (ET2000)/Rectangular (ET Plus) impact head.
- Rectangular holes in first rail allow for attachment of the tabs of the cable anchor bracket.

Terminal Grading Details

A terminal is most likely to perform best when a vehicle is stable at the moment of impact. There are three grading areas around guardrail terminals to help achieve the desired performance: advance, adjacent, and run-out distance; these are highlighted on figure below.

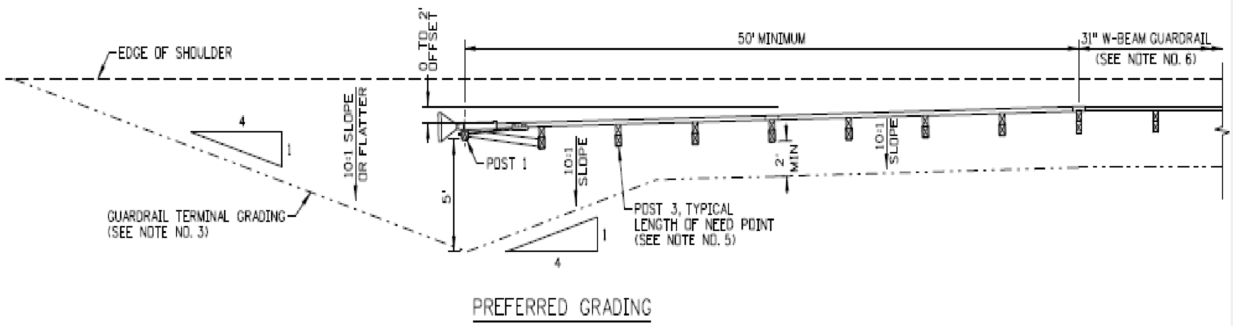


Terminal Grading Areas

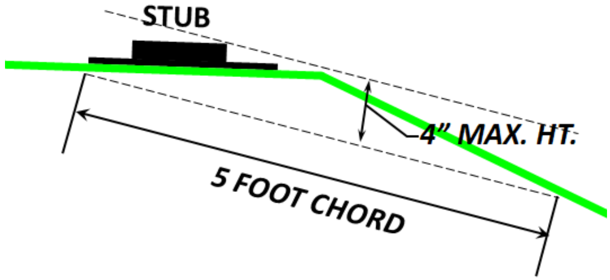
When a grading platform is built, its design and construction should blend with the original embankment. Note that the areas approaching and immediately adjacent to the terminal should be 10:1 or flatter, as shown on ITD Standards; the figure below shows an example from 612-8.

Important: Project will require separate pay item based on quantity (cu. yd. or ton) of grading material needed around the terminal, properly compacted.

Example Grading – Standard. Drawing. 612-8



A second consideration for terminal grading is the stub height criteria, as the figure below shows. Any hardware remaining after the vehicle impact should not exceed this stub height criteria of 4 in.



Stub Height Criteria

Terminal Installation

Review the following items for a proper installation:

- Grading should be appropriate.
- Stub height criteria should be satisfied.
- All parts should be for the specific model being installed.
- For breakaway cable anchorages:
  - Top of post 1 must be able to separate from its base for end-on impacts — to release the cable.
  - Properly orient and restrain bearing plate on the cable at post 1 so that it remains in that position. The bearing plate must not be buried.
- For energy-absorbing, compression-based systems with impact heads:
  - Firmly seat the rail panel into the head.
  - System should be on a straight line for its full length.
  - Proper cable anchor bracket attachment to the rail must allow for release of anchor bracket when hit by the impact head.
  - No bolt through the rail at post 1.
  - Use rail-to-post bolts only when called for and attach on the correct side of the post.
  - Securely attach the impact head to post 1 (again, no post-to-rail connection).
  - Ensure top of the impact head is parallel with the top of the rail.
  - Tighten anchor cable appropriately.

- All energy-absorbing systems are supposed to be installed on a straight line over the full length of the terminal. Avoid installing energy-absorbing systems on curves unless this requirement can be satisfied.

It is a challenge to remember all the intricacies of properly installing the multitude of systems and models within each system. It is impossible to overemphasize the importance of having and following the **MANUFACTURER'S INSTALLATION MANUAL AND SHOP DRAWINGS** onsite for every installation. Use the checklist at the back of each manual — possibly completed for each unit installed/worked on.

Crash Cushions

Crash cushions are generally used to shield a point obstacle or where space is limited.

There are many approved crash cushions for permanent installations. MASH standards took effect December 31, 2018, with an allowance that if no MASH device could satisfy the site conditions, an NCHRP 350 device may be used.

Crash cushions can be classified by the following

- Sacrificial - designed for a single impact.
- Reusable - some components need to be replaced, but some major components are salvageable.
- Low-maintenance and/or self-restoring - suffer very little damage and are readily restored or self-restoring.

For additional commonly used crash cushions throughout the U.S., visit the FHWA website: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/index.cfm

The ITD has approved the use of the following systems:**QuadGuard and QuadGuard II, NCHRP 350 (Reusable); QuadGuard M10 is MASH (Reusable)**

QuadGuard Elite is low maintenance and self-restoring

For current details of this system, see Manufacturer's Installation/Assembly Manual at website: http://www.energyabsorption.com/products/products_quadguard2_crash.asp

Test Level: NCHRP 350/MASH TL-3

How it works: Hex-foam cartridges (or HDPE cartridges that self-restore for the Elite) crush upon impact, absorbing the energy of the impacting vehicle for end-on hits. Specially fabricated side panels, having four corrugations, mounted on diaphragms, slide back on a single track when struck end-on, but redirect the vehicle in side impacts.

- Pad requirement, - see manufacture's installation manual.
- System is available at various widths for NCHRP 350 versions; MASH is only currently available in 24 in. width.
- Two types of cartridges (and two materials, depending if Elite) — number and placement depend on speed; refer to installation manual.

Trinity Attenuating Crash Cushion (TRACC) — NCHRP 350 (Reusable)

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:
http://www.highwayguardrail.com/products/tracc.html

Test Level: NCHRP 350 TL-3

How it works: Consists of a series of W-beam fender panels and an impact face that absorbs energy by cutting metal plates on the top sides of the guidance tracks when forced backward in an end-on impact. Pad required; see manufacture's installation manual

TAU-II and TAU II-R (reusable) — NCHRP 350/MASH

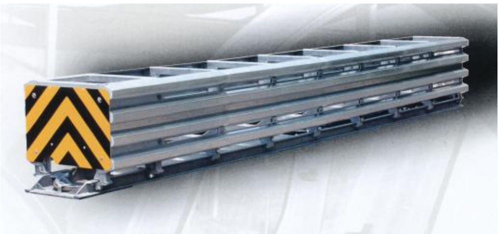
For current details of this system, see Manufacturer's Installation/Assembly Manual at website:
http://www.barriersystemsinc.com/tau-ii-crash-cushion

How it works: Energy-absorbing elliptical cartridges crush (reusable cartridges for the II-R) upon impact. Thrie-beam panels slide back when struck end-on and redirect vehicles when impacted on the side. System anchored at the front and rear and a cable between them.

- Pad required — see manufacture's installation manual
- System is available at various widths at NCHRP 350; currently one width available for MASH
- Two types of cartridges — number and placement depend on speed; refer to installation manual.

SCI Smart Cushion Innovation — MASH

For current details of this system, see Manufacturer's Installation/Assembly Manual at website:
http://workareaprotection.com/attenuators/



How it works: Internal cables and a hydraulic cylinder provide resistance to stop a vehicle, within test criteria speed, before it reaches the end of the cushion's usable length. Side impacts are redirected by the steel panels.

- Pad requirement — see manufacture's installation manual.
- General repair parts consist of replacing shear pins.

QUEST — NCHRP 350 (Reusable)

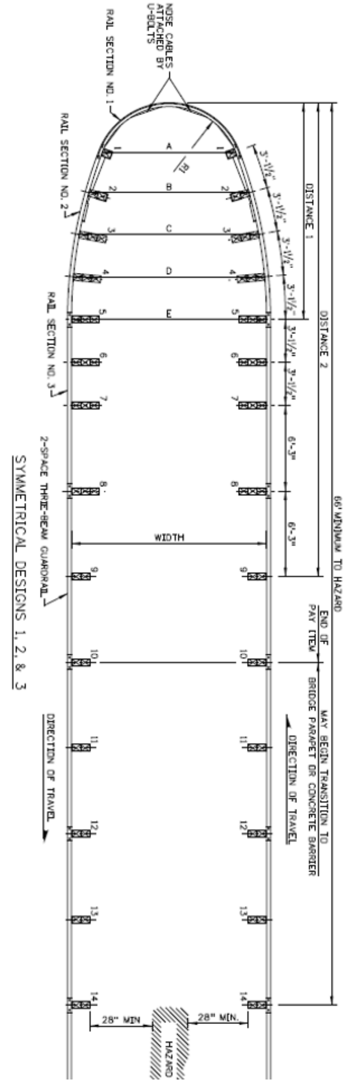
http://www.energyabsorption.com/products/products_questimpact.asp

Test Level: NCHRP 350 TL-3

How it works: Consists of a series of W-beam fender panels supported by diaphragms with a trigger mechanism at the nose that releases the front assembly that absorbs energy by crushing the side tubing. Requires a paved pad.

For water-filled or sand-filled crash cushions, see manufacturer's literature and installation manual. Note that these systems are NOT redirectional and impacts along the sides may pass through.

ITD also uses a *bullnose* crash cushion (Standard 613-1) to terminate the ends of two rather widely separated runs of guardrail. This is a sacrificial system that requires 66 ft of separation between the front and the hazard being shielded.



Transitions — from W-beam to Rigid Barrier/Bridge Rail

When a semi-rigid barrier precedes a rigid barrier, a gradual stiffening transition typically occurs between the two systems. Details for a transition are shown on Standard 612-11 for the Thrie-beam connection from the MGS system to a rigid concrete barrier/bridge rail.

Regardless of the system (*old* or MGS), transition details include the following four essential elements:

1. Strong structural connection of the steel beam to the concrete (to provide for tension continuity).
2. Additional, and typically larger posts.
3. Nested W-beam or nested Thrie-beam.
4. Some design to reduce snagging of the wheel on the rigid barrier (typically a curb or rubrail [or flared-back bridge parapet). Note that any curb is part of the transition design (and does not violate any guidance for standard runs of guardrail).

Although the Standard Drawings may not be applicable to all situations encountered in the field, including these four elements might provide an acceptable transition; coordinate with the appropriate design staff.

There also needs to be a transition from cable to W-beam. A generic transition is an overlap of the systems with a spatial separation of systems of at least 8 ft so as not to redirect an impacting vehicle into the terminal, and sufficient overlap length to prevent a vehicle from passing through the overlap.

Special Designs

Turnout Conflicts

Leaving an opening in a standard run of guardrail for a turnout conflict like a driveway or access road presents a difficult situation for the designer. A design was developed that successfully sustained a direct hit — although only at 50 mph. The design, which can go from an 8.5 ft to a 35 ft radius, used weakened wood posts (CRT) through the radius. On impact, the rail wrapped around the vehicle, safely decelerating it. This design, in Standard 612-3, also requires a special anchor to develop adequate tension and a large clear area behind the rail (though it could have a 2:1 slope). The figure below illustrates the installation.

Omitted Post

As with any special design, only omit a post in special circumstances: only omit in a standard run of guardrail and only with the engineer's approval.

The **MGS** has been developed where single posts may be omitted in runs of MGS W-beam guardrail without any modifications to the typical MGS system (i.e., no weakened posts, no nested rail elements, no special posts, etc.), but always consider the following:

1. A minimum length of 50 ft is required between omitted posts, a terminal, or other special design.
2. Omitted posts cannot be used **within** transitions**,** terminals, or special designs.
3. There are no curbs higher than 2 in.
4. Always consider the additional deflection.

Long-Span Guardrail System

The long-span guardrail design is an alternate treatment that has been tested to span low-fill culverts (or other impediments to driving posts) in lieu of attaching posts to the top of these structures, with a maximum of 3 posts omitted. As with the Omitted- Post design, only use the long-span system in a standard run of guardrail (not in the transition section, terminal, etc.). Where using the long-span design, it is important to verify that no fixed object protrudes more than 2 in. above the ground within the deflection area (8 ft for the MGS design) behind the system, as well as the 50 ft minimum spacing requirement, as identified under the omitted post above.

The MGS long-span design uses three CRT posts on each side of the opening, but NO nesting of rail.

A similar design for a 25 ft span is available for the *old* system with the addition of 100 ft of nested rail and double blocks with the CRT posts.

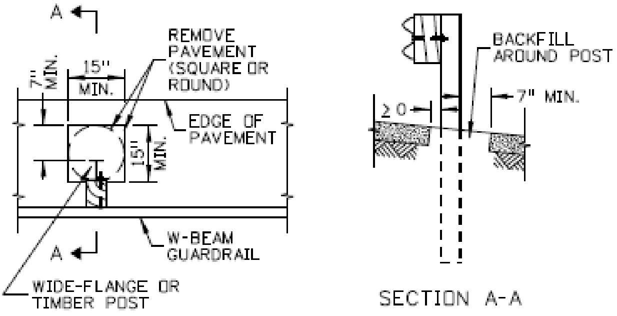
Again, with any leftout post(s) design, one must be aware of the additional deflection – up to 94 in. for three posts removed - which must be taken into consideration.

Extra Blocks

It is acceptable to use double blocks (up to 16 in. deep) to increase post offset and avoid obstacles without any limit to the number of posts. Under special circumstances, use additional blocks (up to 24 in. depth) at one or possibly two posts.

Leaveouts for Posts in Structural Pavement

In order for a post to move backward before failing (as is intended), the support around the post should not be rigid; therefore, provide leave-outs in any structural pavement surrounding a post. A minimum *leave-out* area in the structural pavement will allow at least 7 in. of post deflection at the ground line, as called for in the Standard 612-1, sheet 4.

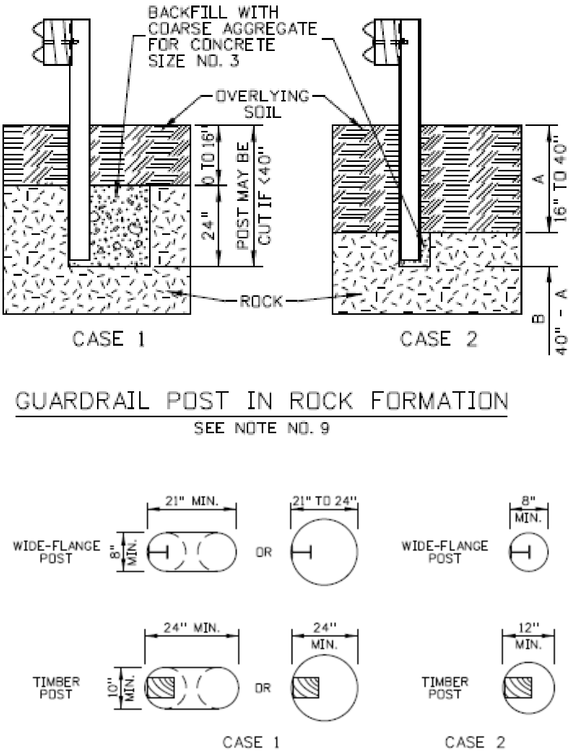


GUARDRAIL POST IN PAVEMENT

SEE NOTE NO. 9

Guardrail Posts in Rock

When encountering rock at a single guardrail post, use the appropriate omitted-post design for either the MGS system or the *old* system with nested rail. The MGS long-span design may be used when rock is encountered at three or fewer guardrail posts. Where rock is encountered at more than three guardrail posts, place the posts in cored holes, as shown on Standard 612-1, sheet 4, and as shown below.

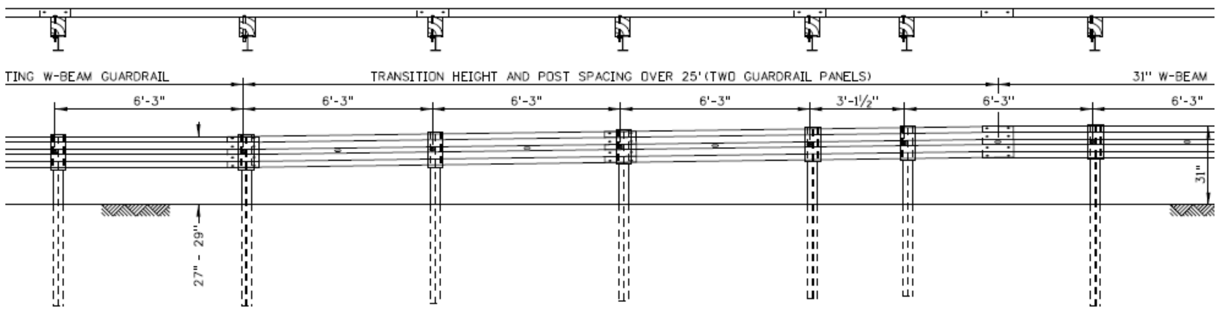


Detail for Posts in Rock

Transitions from *old* W-beam to MGS System

For situations where there is a need to transition between the two systems, plan to transition from an *old* height or terminal to the 31 in. MGS over the span of two 12 ft., 6 in. pieces of W-beam rail, as shown on Standard 612-1, sheet 3, below.

Standard 612-1 MGS Height Transition Details



TRANSITION TO 31" W-BEAM GUARDRAIL

SEE NOTE NO. 18

Maintenance

Keep guardrail systems in reasonable working condition so they are able to function as designed. Some deterioration occurs as a result of crash damage and environmental degradation. Much of this wear can be considered *cosmetic* and may not measurably affect barrier performance. However, some kinds of damage may significantly degrade performance, such as those listed below in the Longitudinal Barrier Damage and Terminal Damage sections. Repair of these types of damage should be made in a reasonable time frame. It is important to assess, prioritize, and schedule identified damaged barrier sites.

General Guidelines

The following are General Guidelines for maintenance:

- Delineate the area of damage to warn the motorists as soon as practical after the discovery/notification of the impact. For some types of damage, such as a ruptured rail or a terminal left in a condition such that it does not function and/or is not crashworthy, schedule repair as soon as practical. To mitigate a blunt rail end condition, it is recommended that the rail be unbolted from several posts and the leading end dropped to the ground. This will avoid exposing a blunt end condition until the installation can be repaired.

- Review damaged guardrail as soon as reasonable to determine the scope of repair based on individual site conditions.
- If damage to non-standard barrier requires reconstructing a significant portion of the run, consider upgrading the entire run to current standards.
- If a significant length of substandard height guardrail is damaged or deteriorated and the whole system is not being upgraded, repair the damaged or deteriorated length to the latest standard for **that** system.

Agencies should also strive to repair minor damage (if more than 25 ft) to the latest standard for that system.

National Guidelines for W-Beam System Maintenance

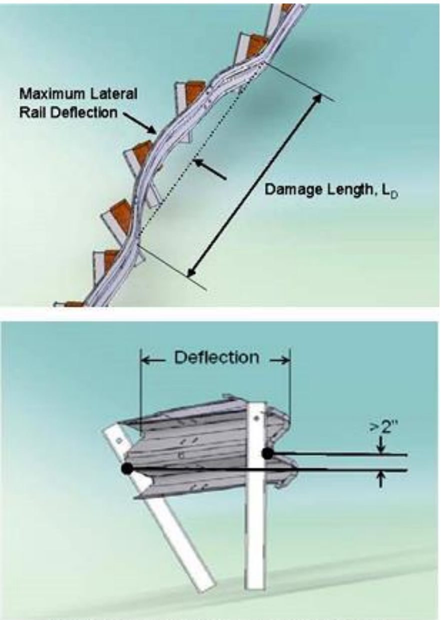
The following pages consist of excerpts from NCHRP Report 656, *Criteria for the Restoration of Longitudinal Barrier*. Note that the types and degree of damage to the barrier itself and to barrier terminals is prioritized as High, Medium, or Low. Use these rankings, along with the perceived likelihood of a second impact — at the crash-testing criteria of high speed, high angle — in the same location to set repair priorities**. Note: These evaluations were based on analysis of the *old* system, not the MGS, under NCHRP 350 testing. (For example, MGS will still function well with one post missing.)**

Repair priority scheme

Priority Level	Description
High	A second impact results in unacceptable safety performance, including barrier penetration and/or vehicle rollover.
Medium	A second impact results in degraded but not unacceptable safety performance.
Low	A second impact results in no discernible difference in performance from an undamaged barrier.

W-beam Barrier Repair Threshold

Damage Mode: Post and Rail Deflection

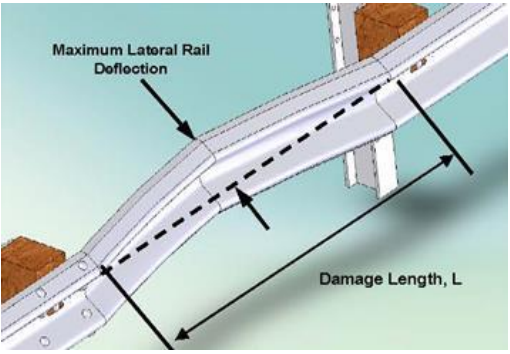


(Weak Post W-Beam Shown Only for Clarity. Each measurement taken at rail middle fold)

Relative Priority	Repair Threshold
High	One or more of the following thresholds: • More than 9 in. of lateral deflection anywhere over a 25 ft length of rail. • Top of rail height 2 or more inches lower than original top of rail height.
Medium	6–9 in. lateral deflection anywhere over a 25 ft length of rail.
Low	Less than 6 in. of lateral deflection over 25 ft length of rail.

W-beam Barrier Repair Threshold

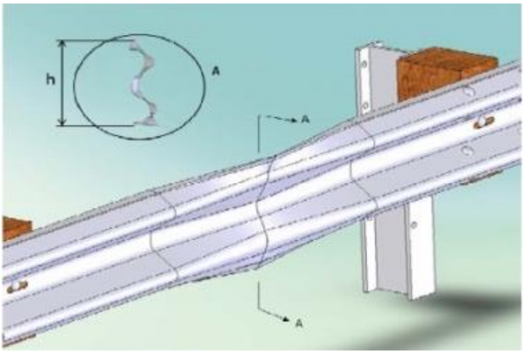
Damage Mode: Rail Deflection Only



Relative Priority	Repair Threshold
Medium	6–9 in. of lateral deflection between any two adjacent posts. Note: For deflection over 9 in., use post/rail deflection guidelines.
Low	Less than 6 in. of lateral deflection between any two adjacent posts.

W-beam Barrier Repair Threshold

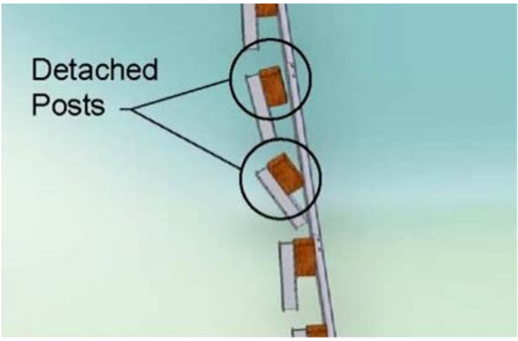
Damage Mode: Rail Flattening



Relative Priority	Repair Threshold
Medium	One or more of the following thresholds: • Rail cross-section height, *h*, more than 17 in. (such as may occur if rail is flattened). • Rail cross-section height, *h*, less than 9 in. (such as a dent to top edge).
Low	Rail cross-section height, *h*, between 9 and 17 in.

W-beam Barrier Repair Threshold

Damage Mode: Posts Separated from Rail



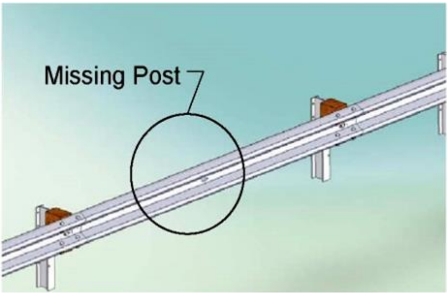
Note:

1. If the blockout is not firmly attached to the post, use the missing blockout guidelines.
2. Damage should also be evaluated against post/rail deflection guidelines.

Relative Priority	Repair Threshold
Medium	One or more of the following thresholds: • 2 or more posts with blockout attached with post-rail separation less than 3 in. • 1 or more post with post-rail separation which exceeds 3 in.
Low	1 post with blockout attached with post-rail separation less than 3 in.

W-beam Barrier Repair Threshold

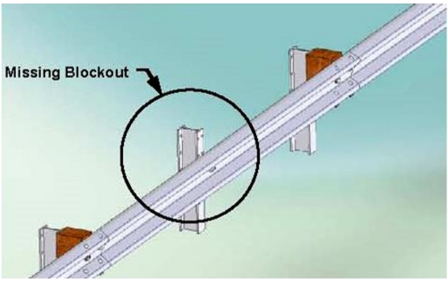
Damage Mode: Missing/Broken Posts



Relative Priority	Repair Threshold
High	One or more posts: • Missing, • Cracked across the grain, • Broken, • Rotten, or • With metal tears.

W-beam Barrier Repair Threshold

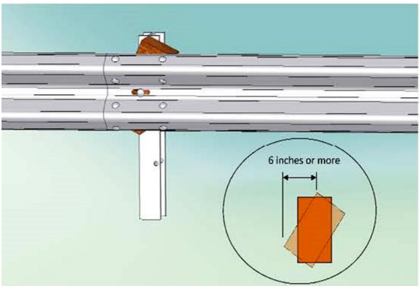
Damage Mode: Missing Blockout



Relative Priority	Repair Threshold
Medium	Any blockouts • Missing, • Cracked across the grain, • Cracked from top or bottom blockout through post bolt hole, or • Rotted.

W-beam Barrier Repair Threshold

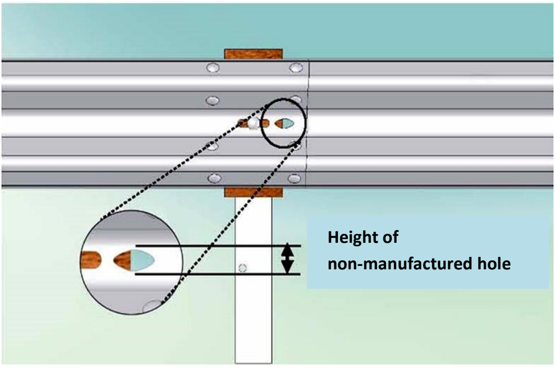
Damage Mode: Twisted Blockout



Relative Priority	Repair Threshold
Low	Any misaligned blockouts, top edge of block 6 in or more from bottom edge. Note: Repairs of twisted blockout are relatively quick and inexpensive.

W-beam Barrier Repair Threshold

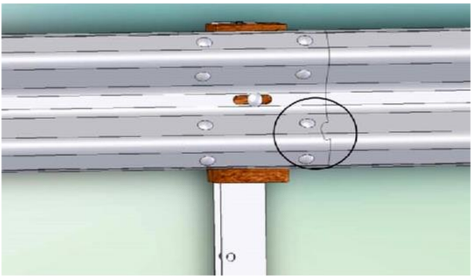
Damage Mode: Non-Manufactured holes (such as crash-induced holes, lug-nut damage, or holes rusted-through the rail).



Relative Priority	Repair Threshold
High	One or more of the following thresholds: • More than 2 holes less than 1 in. in height in a 12.5 ft length of rail. • Any holes greater than 1 in. in height. • Any hole that intersects either the top or bottom edge of the rail.
Medium	1–2 holes less than 1 in. in height in a 12.5 ft length of rail.

W-beam Barrier Repair Threshold

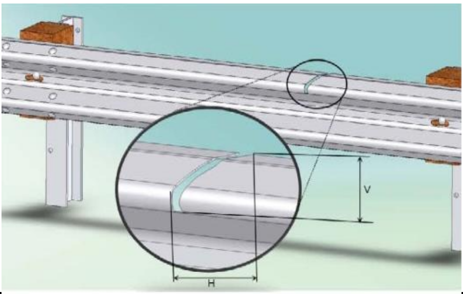
Damage Mode: Damage at Rail Splice



Relative Priority	Repair Threshold
High	More than 1 splice bolt: • Missing, • Damaged, • Visibly missing any underlying rail, or • Torn through rail.
Medium	1 splice bolt: • Missing, • Damaged, • Visibly missing any underlying rail, or • Torn-through rail.

W-beam Barrier Repair Threshold

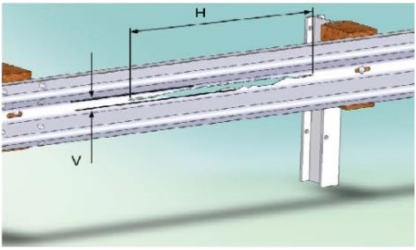
Damage Mode: Vertical Tear



Relative Priority	Repair Threshold
High	Any length vertical (transverse) tear.

W-beam Barrier Repair Threshold

Damage Mode: Horizontal Tear

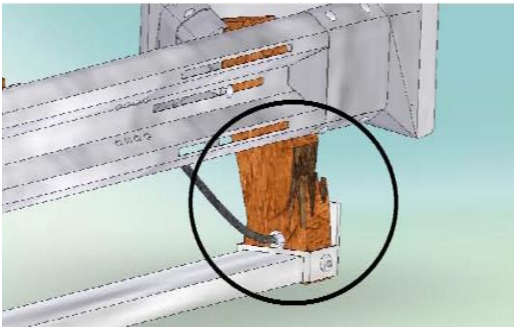


Relative Priority	Repair Threshold

Medium	Horizontal (longitudinal) tears greater than 12 in. long or greater than 0.5 in. wide. Note: For horizontal tears less than 12 in. in length or less than 0.5 in. in height, use the non-manufactured holes guidelines.

Terminal Repair Threshold

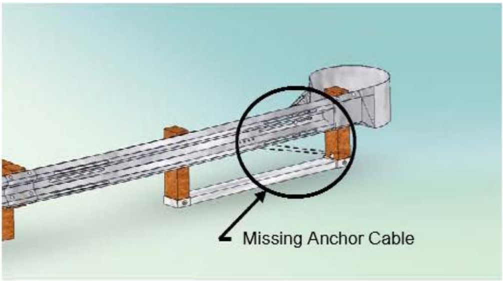
Damage Mode: Damaged End Post



Relative Priority	Repair Threshold
High	Not functional (sheared, rotted, cracked across the grain).

Terminal Repair Threshold

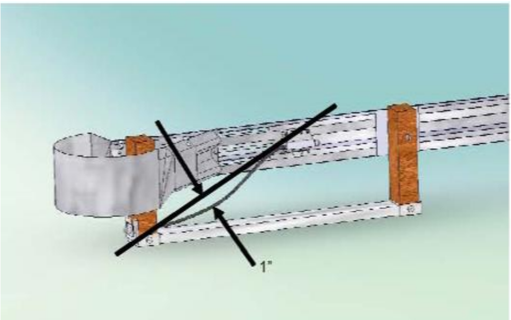
Damage Mode: Anchor Cable



Relative Priority	Repair Threshold
High	Missing.

Terminal Repair Threshold

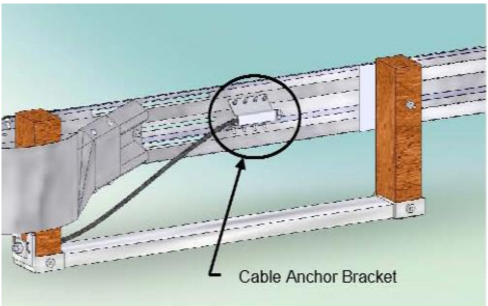
Damage Mode: Anchor Cable



Relative Priority	Repair Threshold
Medium	More than 1 in. of movement when pushed down by hand.

Terminal Repair Threshold

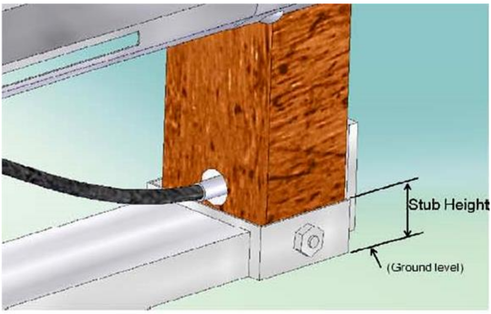
Damage Mode: Cable Anchor Bracket



Relative Priority	Repair Threshold
Medium	Loose or not firmly seated in rail.

Terminal Repair Threshold

Damage Mode: Stub Height

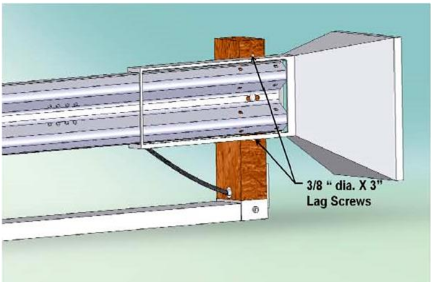


Relative Priority	Repair Threshold
Medium	Height which exceeds 4 in.

Terminal Repair Threshold

Damage Mode: Lag Screws

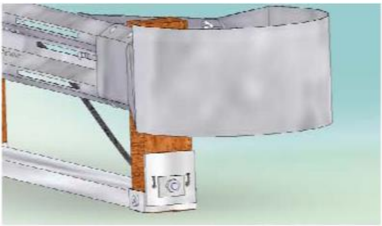
(Energy-absorbing Terminals Only)



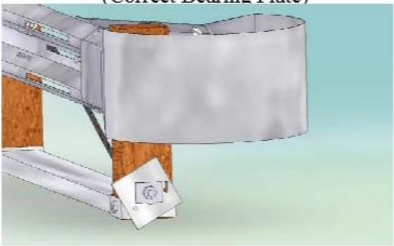
Relative Priority	Repair Threshold
High	Missing or failed lag Screws

Terminal Repair Threshold

Damage Mode: Bearing Plate



(Correct Bearing Plate)

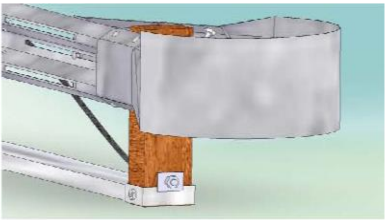


(Misaligned Bearing Plate)

Relative Priority	Repair Threshold
Medium	Loose or misaligned.

Terminal Repair Threshold

Damage Mode: Bearing Plate



Relative Priority	Repair Threshold
High	Missing bearing plate.

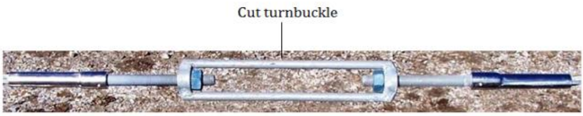
Note: Although not included in NCHRP 656, improper seating of the rail in an extruder head terminal (as shown below) will not allow the terminal to function properly in a crash and could penetrate a vehicle during an impact. When identified, correct this condition at the earliest opportunity.

Improper seating of rail into head

Cable Barrier Guidelines

Cable barrier systems are designed to contain and redirect an impacting vehicle while minimizing the forces on the vehicle and its occupants. Proper maintenance includes checking that the cables are properly tensioned and at the correct height.

- **Routine tension check**. Perform this check even in the absence of an impact, but it is particularly important during the first few years following the installation — at least once a year.
- **Keep the cable intact**. In the event of a crash resulting in a vehicle becoming entangled in the cable, keep the cable intact. Only cut the cable when there is a life-or-death situation. Alternatives to cutting the cable include:
  - — Removing the vehicle by towing it in the opposite direction from which it hit the system.
  - — Loosening the cables at the turnbuckles.
  - — Releasing at anchoring points.
  - — Cutting the turnbuckle, which is preferred to cutting the cable. Remove the adjacent posts on either side of the turnbuckle. Ensure personnel are clear of the cable; cut the center of the turnbuckle, as shown below.



Turnbuckle Cut Location

Glossary

Barricade. A device which provides a visual indicator of a hazardous location or the desired path a motorist should take. It is not intended to contain or redirect an errant vehicle.

Barrier. A device which provides a physical limitation through which a vehicle would not normally pass. It is intended to contain or redirect an errant vehicle.

Breakaway. A design feature which allows a device such as a sign, luminaire, or traffic signal support to yield or separate upon impact. The release mechanism may be a slip plane, plastic hinges, fracture elements, or a combination of these.

Bridge Railing. A longitudinal barrier whose primary function is to prevent an errant vehicle from going over the side of the bridge structure.

Clearance. Lateral distance from edge of traveled way to a roadside object or feature.

Clear Zone. The unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles. The clear zone includes shoulders, bike lanes, and auxiliary lanes, except those auxiliary lanes that function like through lanes.

Cost-effective. An item or action taken that is economical in terms of tangible benefits produced for the money spent.

Crash Cushion. Device that prevents an errant vehicle from impacting a fixed object by gradually decelerating the vehicle to a safe stop or by redirecting the vehicle away from the obstacle.

Crash Tests. Vehicular impact tests by which the structural and safety performance of roadside barriers and other highway appurtenances may be determined. Three evaluation criteria are considered, namely (1) structural adequacy, (2) occupant impact severity, and (3) vehicular post-impact trajectory.

Crashworthy. A feature that has been proven acceptable for use under specified conditions either through crash testing or in-service performance.

Design Speed. A selected speed used to determine the various geometric design features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the highway.

Drainage Feature. Roadside items whose primary purpose is to provide adequate roadway drainage such as curbs, culverts, ditches, and drop inlets.

End Treatment. The designed modification of the end of a roadside or median barrier.

Energy-Absorbing Terminals, Terminals that can stop vehicles in relatively short distances in direct end-on impacts (usually 50 ft or less depending on type of terminal).

Flare. The variable offset distance of a barrier to move it farther from the traveled way; generally in reference to the upstream end of the barrier.

Hinge. The weakened section of a sign post designed to allow the post to rotate upward when impacted by a vehicle.

Impact Angle. For a longitudinal barrier, it is the angle between a tangent to the face of the barrier and tangent to the vehicle's path at impact. For a crash cushion, it is the angle between the axis of symmetry of the crash cushion and a tangent to the vehicles path of impact.

Impact Attenuator. See Crash Cushion.

Length of Need (LON). Length of a longitudinal barrier needed to shield an area of concern.

Longitudinal Barrier. A barrier whose primary function is to prevent penetration and to safely redirect an errant vehicle away from a roadside or median obstacle.

Median. The portion of a divided highway separating the traveled ways for traffic in opposite directions.

Median Barrier. A longitudinal barrier used to prevent an errant vehicle from crossing the median.

Non-Energy-Absorbing Systems. Systems that will allow an unbraked vehicle to travel 150 ft or more behind and parallel to guardrail installations or along the top of the barrier when struck head-on at high speeds.

Non-Recoverable Slope. A slope which is considered traversable but on which an errant vehicle will continue to the bottom. Embankment slopes between 3H:1V and 4H:1V may be considered traversable but non-recoverable if they are smooth and free of fixed objects.

Offset. Lateral distance from the edge of traveled way to a roadside object or feature.

Operating Speed. The highest speed at which reasonably prudent drivers can be expected to operate vehicles on a section of highway under low traffic densities and good weather. This speed may be higher or lower than posted or legislated speed limits or nominal design speeds where alignment, surface, roadside development, or other features affect vehicle operations.

Operational Barrier. One that has performed satisfactorily in full-scale crash tests and has demonstrated satisfactory in-service performance.

Recoverable Slope. A slope on which a motorist may, to a greater or lesser extent, retain or regain control of a vehicle. Slopes flatter than 4H:1V are generally considered recoverable.

Recovery Area. Generally synonymous with clear zone.

Roadside. That area between the outside shoulder edge and the right-of-way limits. The area between roadways of a divided highway may also be considered roadside.

Roadside Barrier. A longitudinal barrier used to shield roadside obstacles or non-traversable terrain features. It may occasionally be used to protect pedestrians or *bystanders* from vehicle traffic.

Roadside Signs. Roadside signs can be divided into 3 main categories: overhead signs, large roadside signs, and small roadside signs. Large roadside signs may be defined as those greater than or equal to 50 ft^2 in area. Small roadside signs may be defined as those less than 50 ft^2 in area.

Roadway. The portion of a highway, including shoulders for vehicular use.

Shielding. The introduction of a barrier or crash cushion between the vehicle and an obstacle or area of concern to reduce the severity of impacts of errant vehicles.

Shy Line Distance. The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an obstacle by the typical driver to the extent that the driver will change the vehicle’s placement or speed.

Slope. The relative steepness of the terrain expressed as a ratio or percentage. Slopes may be categorized as positive (backslopes) or negative (foreslopes) or as a parallel or cross slope (in relation to the direction of traffic).

Test Level. A set of conditions, defined in terms of vehicular type and mass, vehicular impact speed, and vehicular impact angle that quantifies the impact severity of a matrix test.

Temporary Barrier. Temporary barriers are used to prevent vehicular access into construction or maintenance work zones and to redirect an impacting vehicle so as to minimize damage to the vehicle and injury to the occupants while providing worker protection.

Traffic Barrier. A device used to prevent a vehicle from striking a more severe obstacle or feature located on the roadside or in the median or to prevent crossover median accidents. As defined herein, the four classes of traffic barriers are roadside barriers, median barriers, bridge railing, and crash cushions.

Transition. A section of barrier between two different barriers, or more commonly, where a roadside barrier connects to a bridge railing or to a rigid object such as a bridge pier. The transition should produce a gradual stiffening of the approach rail so vehicular pocketing, snagging, or penetration at the connection can be minimized.

Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Traversable Slope. A slope from which a motorist will be unlikely to steer back to the roadway but may be able to slow and stop safely. Slopes between 3H:1V and 4H:1V generally fall into this category.

Warrants. The criteria by which the need for a safety treatment improvement can be determined.

Resources

Idaho Department of Transportation

- Standard Specifications
- Standard Plans
- Design Manual
- Roadside Safety Manual
- Construction Manual
- Maintenance Manual
- Qualified Product List

Federal Highway Administration (FHWA)
https://www.fhwa.dot.gov/

- FHWA Hardware Policy and Guidance
  http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/
- FHWA Longitudinal Barriers
  http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/
- FHWA Resource Charts
  http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/
- NHTSA FARS website:
  http://www-fars.nhtsa.dot.gov/Main/index.aspx

American Association of State Highway and Transportation Officials (AASHTO)
https://www.transportation.org/

- AASHTO, *Roadside Design Guide*, 2011
- *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2009
- AASHTO, *Manual for Assessing Safety Hardware*, 2016 (MASH16)
  AASHTO Task Force 13 website http://www.tf13/org
- *Guide to Standardized Highway Barrier Hardware*
- *Guide to Standardized Bridge Rail Hardware*
- *W-beam Guardrail Repair Guide*

- *Guide to Transitions*

Roadside Safety Pooled Fund sites:

- MWRSF: http://mwrsf-qa.unl.edu/
- TTI: http://www.roadsidepooledfund.org/

National Cooperative Highway Research Program (NCHRP)
http://www.trb.org/

- Research Projects
  http://www.trb.org/NCHRP/Public/NCHRPProjects.aspx
- NCHRP 500 Volume 6: *A Guide for Addressing Run-Off-Road Collisions*

NOTES